SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1923.

GENERAL PHYSICS.

241. *A New Form of Direct-Reading Barometer.* **H. P. Waran.** (Roy. Meteorolog. Soc., J. 48. pp. 287–291, Oct., 1922.)—The Kew pattern station barometer was a great improvement on the Fortin type, since it eliminated the necessity of adjusting the surface of the mercury in the cistern before taking an observation. But even in this type the top setting of the vernier scale to the level of the mercury column is essential for taking a reading and requires extreme care in order to avoid errors due to parallax and other causes. If the necessity for this adjustment could also be eliminated, it would evidently be a great advantage. The author has devised, and here describes with figures, a type of barometer designed to achieve this desideratum. It is a modified syphon barometer, with its top and bottom tubular reservoirs of equal cross-sectional area and inclined to the vertical by an equal amount. An experimental form of the apparatus kept under observation for some months entirely justified expectations, by following the readings of a standard Fortin barometer, within a margin of a tenth of a millimetre. E. F.

242. *Investigation of the Tensions in Bent Beams.* **E. Asch.** (Zeits. techn. Physik, 3. 9. pp. 294–305, 1922.)—The present paper employs the method of parallel polarised, light for establishing the tension gradients and the measurement of tensions in bent strips previously straight. Earlier work by Mesnager, Hönigsberg, Aue, and Coker is referred to briefly, and precedes a mathematical discussion of the problem. Following this comes a description of the experimental arrangements and an exposition of the physical basis of the investigation. The experimental work itself is then described, the material used being celluloid. Section 1, deals with the trajectory diagrams; Section 2, with the tension magnitudes produced by simple bending; Section 3, with compression tensions; and Section 4, with the influence of cutting tensions; Section 5, discusses the accuracy of the function introduced for the boundary on edge-effect in the mathematical formula. In a review of the results, the author points out that celluloid is a homogeneous substance, and that the problem exists as to the extent to which a comparison with technical building materials is allowable, since the double-refraction effect of such homogeneous bodies is proportional to the tension and not to the displacement, although the tension and displacement ellipsoids are identical. Further, the optical behaviour of such transparent bodies for plane states of tension is independent of the elastic constants of the materials. Various difficulties are referred to and discussed. H. H. Ho.

243. *Elasticity and Symmetry of Quartz at High Temperatures.* **A. Perrier and B. de Mandrot.** (Comptes Rendus, 175. pp. 622–624, Oct. 16. **Errata,** p. 1006, Nov. 20, 1922. Arch. des Sciences, 4. pp. 367–369, Sept.–Oct., 1922. Abstract.)—It having been concluded on hypothetical grounds that there is a temperature at which piezo-electricity disappears, observations have been made on quartz at the point $\alpha\beta$. This has necessitated a study of its elasticity as a function of temperature. The tension constants of quartz under ordinary conditions and up to 1200° have been determined in four directions: those of the binary and of the ternary axis, and in two directions at right angles to the binary axis and at 50° on each side of the optical axis. Laminæ were prepared of about $0\cdot7\times7$ mm.^{2} in section and from 70 mm.–80 mm. in length. They were placed on two supports 40 mm.–50 mm. apart and flexed by a known weight acting at the centre. The flexure was examined by the Koenig process (reading a scale by means of two plane mirrors fixed at the extremities of the laminæ). A table is given showing the constants thus determined. They correspond with isothermal deformations and under ordinary conditions differ but slightly from the adiabatic constants. It is to be observed, however, that in an interval of a few degrees below the point $\alpha\beta$ deformation and recovery show a marked lag, equilibrium being regained only after a lapse of from one to two minutes. Apart from this perfectly normal and easily explained phenomenon, complete reversibility was found, whether as a function of strain or of temperature. An examination of the figures at once reveals the considerable range of variation of the moduli. Perpendicular to the axis it extends from the simple to the quadruple. P. Curie found that in the vicinity of ordinary conditions the piezo-electric modulus is independent of the temperature. This fact, in conjunction with the results regarding elasticity here given, leads to the conclusion that under similar conditions the electric impulse generated by deformation at right angles to the optical axis is due solely to this deformation. The figures relating to the directions ± 50° lead to a very definite conclusion touching the respective symmetries of the states α and β. A table shows that the very considerable divergence between the two directions diminishes rapidly and disappears at 576°. Beyond that point the moduli are identical. This fact proves absolutely that at the transition point the crystal passes from rhombohedric to hexagonal symmetry and that therefore the elasticity of the quartz β has a symmetry of revolution. E. F.

244. *The Effect of Variation in Weight of the Riders and Plummets of the Westphal Balance upon the Accuracy of Specific-Gravity Determinations.* **E. A. Tschudy.** (Am. Chem. Soc., J. 44. pp. 2130–2135, Oct., 1922.)—Accurate specific-gravity determinations with the Westphal balance are possible only when the weight of water displaced by the plummet at 15°, and the weights of the riders have an exact multiple relationship among themselves. Variations in weight of the riders which disturb this relationship produce errors, often of considerable magnitude, in specific-gravity determinations. Inaccurate plummet thermometers are also a source of error. The magnitude of ordinary variation in weight of riders and plummets has been ascertained, and equations have been derived for computing the correction which must be applied to any indicated balance reading in order to obtain the true specific gravity of liquids, lighter or heavier than water. Application of the corrections for any specific system of riders to indicated balance readings is facilitated by the construction and use of correction graphs. AUTHOR.

245. *Observations on the Construction and Use of the Steele-Grant Microbalance.* **E. J. Hartung.** (Phil. Mag. 43. pp. 1056–1064, June, 1922.)—Particulars are given of a microbalance constructed according to the design of Steele and Grant. With a double-triangle beam a relative working sensitiveness of 1 part in 4×10^7 was obtained, so that trustworthy weighing could be obtained up to $4\mu (1\mu = 10^{-6}$ mg.). Results are also given for a balance with a fibre suspension instead of a knife-edge. W. R. C.

246. *Protection of Brass Weights.* **J. J. Manley.** (Phil. Mag. 44. pp. 948–950, Nov., 1922.)—The weights were first lightly tooled, then polished; next, they were heated in a semi-luminous gas flame until they were nearly red hot, and then plunged into boiled linseed oil, where they were left to cool. They were then washed with turpentine and polished with old linen. After 16 years' continuous use no readjustment was required. Present-day coal gas, however, is unsuitable for this purpose owing to the admixture of sulphur compounds, hence a new method had to be devised. A "vitreosil" crucible was loosely charged with asbestos fibre. An inverted vitreosil lid was placed on the fibre, and on this were arranged three pointed pieces of porcelain or fused quartz for supporting the weights. The weight, cleaned, polished, and coated with linseed oil, was then placed within the crucible, which was then covered with a lid, and the whole heated in a Bunsen flame. When the weight assumed a golden tint the process was completed, the crucible allowed to cool, the weight rubbed with an old silk handkerchief, and readjusted. T. C. H.

247. *Surface Tension, Surface Energy, and Latent Heat.* **J. Satterly.** (Roy. Soc. Canada, Trans. 16. pp. 83–92, 1922.)—The capillary constant was expressed by Waterson in 1858 in a manner very different from that employed at present. He showed that the volume of water raised by a water line 20 inches long was 0·1505 cu. in., and weighed 38 grains at 86° F. (30° C.). The value of the quotient of capillarity Q was 132·9. According to modern methods he was about 30 % in error. There are 214,800,000 layers of a molecule in one cubic inch. From the expression $m^3 = (6/QL)^3$, where L = the product of the latent heat by 12 times 772, Q = the quotient of capillarity, and m^3 = the molecular volume expressed with reference to a cubic inch as unit, Waterson states that the product mQL has the same constant value for all liquids at any temperature, whence the latent heat can be computed from the capillarity, and vice versa. Hammick in 1919 obtained the equation $6TV/d = L_1$; where T = surface tension, d = molecular diameter, V

= volume of one gramme-molecule, and L_1 = internal latent heat of vaporisation of the gramme-molecule. Taylor in 1921 applied the formulæ to spheres, and deduced the number

$$n = \left(\frac{L}{T}\right)^3 \frac{m\rho^3}{36\pi}$$

where L = latent heat of vaporisation per gramme at θ°A, T = the tension of the envelope at θ°A, m = molecular weight, and ρ = the sensity of the liquid at θ°A; but his formula is not true. The author thinks that in these calculations surface energy should be used and not surface tension, and advances a mathematical proof of his statement.

T. C. H.

248. *On the Influence of the Surface-Tension on the Efflux of a Liquid in Jet Form.* **J. Hartmann.** (Danske Vidensk-Selskabs., Med. 11. 8. 1919. Phys. Rev. 20. pp. 728–744, Dec., 1922. Extract.)—Christiansen suggested that surface tension exerts a pressure acting against the pressure causing the flow, so that the Torricelli equation becomes: $v^2 = 2\pi^2\kappa^4r^4g(h - h_0)$. If then κ, the coefficient of effective contraction, is constant v^2 should be a linear function of h, intercepting the $h = 0$ axis at h_0. Experiments with mercury and water, in which the speed of efflux was determined down to low values of h, confirm this theory. With cylindrical holes, straight lines were obtained, but with conical holes the relation is curvilinear because of the decrease of the contraction with the speed; yet both types of curve gave the same value of h_0. With water, holes through paraffin paper were used. When the speed decreased to a critical value for each jet, pulsations began to appear, but these did not affect the speed of efflux. Photographs are given of various jets. As a qualitative confirmation of the theory, ether vapour, which is known to decrease the surface tension of water, was found to decrease h_0 by 18 per cent. According to Christiansen the surface tension is equal to $r\rho g h_0$. The measurements with mercury and water confirmed this relation, as after correcting for the loss of head in the cylindrical hole, the values of the surface tension came out 536 dynes/cm. for Hg at 16° C. and 74 dynes/cm. for water at 10° C. within one per cent. of the accepted values. It is believed the method is capable of higher accuracy, if developed.

AUTHOR.

249. *Boundary Lubrication. The Temperature Coëfficient.* **W. B. Hardy and I. Doubleday.** (Roy. Soc., Proc. 101. pp. 487–492, Sept. 1, 1922.)—In order to overcome the fact that lubricating vapours were given off from the walls of the chamber in which the plate and spherical faced slider were enclosed, a chamber with double walls, the inner being a continuous sheet of nickel, was used. Electric grids between the walls heated the chamber, and the stream of dry air was also heated by passing through a tube of silica, maintained at the required temperature by a coil of wire through which passed a current. Clean faces were studied first. Glass was totally unsuitable, as the physical state of its surface was altered by a small rise of temperature, the coefficient of friction, μ, falling as the temperature rose. Quartz behaved in a similar manner. Steel and bismuth, when clean, showed no change whatever in the friction over the tried range of temperature (15°–110° C.). When the lubricant was fluid throughout the temperature range the friction was independent of the

temperature, but if it was solid over part of the range the effect of temperature was different below and above the melting-point of the solid. The friction fell with a rise of temperature up to melting point, when it fell to zero, but when the lubricant was fully melted the friction suddenly reappeared at a higher level than before discontinuity and remained constant over the remainder of the range. Various lubricants were tried, and the authors offer an explanation of the discontinuity, after certain experiments, and conclude that the friction of quartz and steel lubricated with normal paraffins and related normal acids and alcohols is sensibly independent of the temperature. There is no static friction at the melting-point of a lubricant, i.e. when the lubricant is partly solid and partly melted. The paper is illustrated with curves and tables of data [see Abs. 1478 (1922)].
T. C. H.

250. *The Drainage Error in the Bingham Viscometer.* **W. H. Herschel.** (Optical Soc. America, J. 6. pp. 875–898, Oct., 1922.)—For the accurate determination of absolute viscosity it is usual to employ instruments with glass capillaries, more or less modified from the original form of Ostwald. These instruments differ in the arrangement of the bulbs in which the liquid is measured, and in the manner of filling with a definite working volume. In the instruments of Ostwald and Traube there is a drainage error due to the variation, with the viscosity, of the volume discharged from the bulb. This error is avoided in Lidstone's apparatus by the use of mercury which does not wet the bulb, while in the Ubbelohde form of instrument the flow is into a dry bulb, and the measured volume is independent of the viscosity of the liquid tested. The Bingham viscometer is described in the paper, and is similar to the Ubbelohde in having 2 bulbs so arranged as nearly to eliminate the effect of variations in the density of the liquid and in the use of a constant air pressure to cause the flow. The Bingham viscometer being only used where great accuracy is required, the drainage error is an important factor, and the object of the paper is to estimate its magnitude and the time of flow necessary to render it negligible. Section 2 deals with the calibration of the Bingham viscometer; Section 3 with its use; Section 4 with the Scott viscometer; Section 5 with possible causes of the law values of μ/vt; Section 6 with indications of drainage error of Bingham instrument by comparison with Saybolt and Redwood viscometers; Section 7 with calibration of bulb of Bingham instrument by oils of various viscosities; and Section 8 with methods of avoiding drainage error. It was found that the drainage error is negligible only for comparatively light oils when a sufficiently long time is taken for the discharge. A diagram is given to show the relation between viscosity, time of flow, and per cent. drainage error. The drainage error is shown to be avoided by having the trap on the opposite limb from the bulb which measures the volume discharged. An appendix gives a comparison of viscosities as obtained by the Scott viscometer, and by the Plummet method of Basseches. The latter is described, as it seems unsurpassed as a very rapid though approximate method of measuring the consistency of very viscous or plastic substances.
H. H. Ho.

251. *Viscosity of Liquids and its Theoretical Interpretation.* **L. Brillouin.** (J. de Physique et le Radium, 37. pp. 326–340, Sept., 1922.)—No theoretical interpretation is yet available for the viscosity of liquids or solids—a regrettable circumstance, in view of the ease with which the viscosity of a gas is explained on the kinetic theory—and the introduction to the paper contains a very brief exposition of the latter. Section 2 then discusses the kinetic theory of solids and liquids. Section 3 deals with the influence of elastic waves of thermal movement, Section 4 considers initial viscosity, and Section 5 the influence upon it of temperature. In Section 6 viscosity and calorific conductivity receive attention, while Section 7 is confined to numerical examples. Section 8 examines the experimental data of liquid viscosity, and especially the influence of pressure, in connection with which Faust's experiments, carried out in 1913, are considered in Section 9. Other work is noted in Section 10. In these sections the author has attempted to relate the viscosity of liquids to the general theory for solids and liquids as developed since the work of Einstein and Debye on specific heats. The principle employed was to analyse thermal movement into elastic waves, each of which conveys a portion and so plays a rôle in the viscosity. The result found pointed to the existence of a negative term in the general expression, which diminishes the natural velocity present in the liquid when all thermal movement is absent, and an attempt to state the mechanism producing natural viscosity has been given. This mechanism depends solely on the specific volume of the liquid and at a given volume is found to be independent of the temperature. Here, then, is the most important factor for viscosity, and a formula is given for the residual influence of temperature at constant volume. In this way viscosity and calorific conductivity can be connected by the expression $(\partial\zeta/\partial t)_{\mathrm{v.\,const.}} = -5/3\,\mathrm{J}a/\mathrm{V}^2$, where ζ is the viscosity, a the calorific conductivity, J the mechanical equivalent of heat, and V the speed of the waves. The experimental results, however, have not yet given an accurate verification of this formula, but are of the same order of magnitude. Applications of the theoretical treatment are valid for liquids which do not form complex molecules and also in the realm of high pressures. H. H. Ho.

252. *A Problem in Viscosity: The Thickness of Liquid Films Formed on Solid Surfaces under Dynamic Conditions.* **Research Staff of the General Electric Co., London.** (Phil. Mag. 44. pp. 1002–1014, Nov., 1922.)—The problem of determining the thickness of the liquid layer, coating a body drawn out of a liquid, is of considerable practical importance; as in many important industrial processes solid surfaces are coated with a liquid layer in this way. As a flat plate, or a cylinder of solid moves upward out of the liquid a thin layer of liquid, in contact with it, moves upward with practically the same velocity. The liquid coating drawn up can be divided by a series of surfaces at different distances from the solid, the sections of which in a diagram representing a vertical section are stream lines; and the velocity upwards diminishes as the distance from the surface of the solid increases, until at the outer surface it becomes zero. For an infinite flat plate the forces concerned are those due to viscosity between the layers of liquid, and gravity; the thickness of the liquid coating being given by $t^2 = 2v_0\eta/\rho g$. With a fine wire, of radius r, surface tension is dominant, and gravity is negligible. It is found empirically that $t/r = 4{\cdot}8\,\eta v/\gamma$ in c.g.s. units, where η is the viscosity and γ the surface tension. The results apply to suspensions, if the diameter of the suspended particles is not greater than *t*, and if the effect of the particles in increasing the viscosity is considered. It is not necessary to assume any special cohesion between the solid and the liquid, other than that which prevents slipping at the interface. In practice the liquid coating is solidified on the solid, either by evaporation of volatile constituents, or by cooling; and the thickness determined by weighing. The actual thicknesses found with melted wax were larger than those given by the formulæ, as the cooling of the wax as soon as it leaves the liquid surface increases its viscosity. The observed thicknesses are therefore greater than those calculated from the viscosity of the wax in the bath; the difference, however, is not large, so that the theory is confirmed by the experiments. With wires the layer was found to be unstable, the solidified coating being broken into blobs by the surface tension. These blobs were beautifully symmetrical, and evenly distributed when viewed under a microscope. They are formed after the liquid coating has been withdrawn from the bath. H. N. A.

253. *Laboratory Hypsometers.* **E. F. Mueller** and **T. S. Sligh, Jr.** (Optical Soc. America, J. 6. pp. 958–964, Nov., 1922.)—After briefly reviewing various forms of hypsometers the authors proceed to describe one of their own design. Electric heating was used. The boiler is made of brass tube 5 cm. in diameter and 20 cm. high. From the boiler a steam pipe of 13 mm. diameter brass tube enters the steam space round the thermometer tangentially. The small cross-section of the boiler and the small steam pipe provide for relatively rapid steam flow, thus causing quick removal of air. The upper 5 cm. of the thermometer space is uninsulated to provide surface for condensation, whilst the remainder of the space is provided with an air jacket. The heating coil consists of two sections, connected by a switch either in series or parallel. When the coils are in series on a 110-volt circuit the input is about 125 watts, which maintains just a trace of steam escaping into the air. Tested against a Chappuis hypsometer, no systematic difference was observable between the two instruments. T. C. H.

254. *Weight-Mass Ratios for Bismuth and Zinc.* **C. F. Brush.** (Am. Phil. Soc., Proc. 61. 3. pp. 167–183, 1922.)—The experimental part of a previous paper [see Abs. 449 (1922)] appeared to show that equal masses of bismuth and zinc have not exactly equal weights; in other words, that the *weight-mass* relationship differs in different substances. For instance, a given mass of bismuth appeared to weigh a little more than an equal mass of zinc; or, in pendulum experiments, gravity appears to act more strongly per unit mass on bismuth than on zinc. If established, this would be a fundamental fact of supreme importance, and the present paper is devoted solely to a record of experiments undertaken to test this point. Of the several experiments detailed in the first paper, that of the two gravity pendulums is the simplest and most easily understood, the most accurate and reliable, and has brought out most suggestions of possible sources of error. The latter are all considered in the present paper, the experiments being extended and reviewed; and the conditions as to lengths of rods, also weights and shapes of bobs, have been widely varied. In *every* case the former bismuth-zinc effect (i.e. higher value of *weight-mass ratio* in bismuth than in zinc) has been confirmed, and in *no* instance has there being any negative or equivocal result. The bismuth-zinc effect is of the order of one in 35,000. This value obtained by direct comparison is confirmed by the indirect determinations of the bismuth-iron effect and iron-zinc effect, that is the comparison of bismuth and zinc, each with the third metal, iron. In experiments with direct falls of bismuth and zinc with timing arrangements capable of detecting a hundred-thousandth of a second, bismuth is found to strike the target just a little before the zinc arrives. Fuller details of this apparatus are reserved for another paper. [Cf. negative results by H. A. Wilson in Abs. 2208 (1922).] E. H. B.

255. *Capillarity.* **W. Taylor.** (Nature, 110. pp. 377–378, Sept. 16, 1922.)—A sketch of a theory based on the concept that the bounding surface between mass and not-mass tends to shrink; that when like masses come into contact, the tendency to shrinkage does not exist over the area of contact; and that when unlike masses do so there is a residual tendency to shrinkage of the area of contact. An explanation of capillary-rise and surface spreading in terms of the theory; experimental verifications. A. D.

256. *Surface-Characters of Mercury.* **E. Perucca.** (Comptes Rendus, 175. pp. 519–522, Oct. 2, 1922.)—The fresh surface of mercury changes with the time, approaching a condition of maximum stability; the smallest intrinsic potential, the most electropositive character, the minimum potential energy of the superficial layer, and the minimum superficial tension are considered. The time taken is very short *in vacuo*, longer in a gas, and it is of the order one minute for a pressure of 0·1 mm. and ten minutes for a pressure of 1 mm., being least in hydrogen and greatest in CO_2. If the mercury be prepared *in vacuo* there is no change upon exposure to a gas. A. D.

257. *Turbulence.* **C. Camichel.** (Comptes Rendus, 175. pp. 743–745, Oct. 30, 1922.)—Describes experiments in which the introduction of various obstacles into a fluid stream produces turbulence. No photographs nor diagrams are given. E. H. B.

258. *Discharge of Air through Small Orifices, and the Entrainment of Air by the Issuing Jet.* **J. S. G. Thomas.** (Phil. Mag. 44. pp. 969–988, Nov., 1922.)—The orifices experimented with were made by means of a machine, designed by Charles Carpenter, for the bulk manufacture of single or multiple-orificed injectors, for use in gas burners. The burr produced in punching the holes was removed by rubbing on an oiled stone, and the inner surface of the hole burnished with a cylindrical needle. The velocity of the air set in motion by the jet was measured with a hot wire anemometer of the Morris type. The equation obtained from Lamb's formula [Hydrodynamics, p. 23, 1906], by assuming adiabatic expansion, does not agree with the experimental results obtained for flow through an orifice in a thin plate; but an empirical formula was obtained, which gave consistent results when the diameter of the hole was fairly large compared with the thickness of the disc. Such orifices show the effect of the *vena contracta*, which does not appear when the hole is small as compared with the thickness of the disc. As a result of this the discharge through a hole in a thick disc may be greater than that through one of the same diameter in a thin disc. Under normal conditions the relation between the volume of the entrained air and the pressure at the orifice is approximately linear for low pressures, the curve becoming concave to the pressure axis for higher pressures. This is to be anticipated, as the viscous and frictional drag upon the stream of entrained air increases with the velocity. With some of the orifices used the curves show points of inflexion, the upward slope increasing as the pressure rises, and then diminishing again until the curve is concave to the pressure axis, as in the normal jets. These irregularities, which seem to be due to turbulence in the jet, are of importance, as it is necessary to avoid them in the design of gas-burners. They also probably explain, at least in part, the low-pressure sensitive flames studied by G. A. Sutherland and by C. Bell [Nature, 108. p. 532, 1921. Roy. Soc., Phil. Trans., Part 2, pp. 383–422 (1886) respectively]. The absence of the effect at low pressures is ascribed to the fact that the motion of the gas is so slow that little initial unstable turbulence is impressed on the stream, and any that exists is damped out. At much higher pressures the effect is absent because the passage of the air into the channel approximates to stream-line motion. H. N. A.

259. *Physical and Technical Units.* **J. Wallot.** (Elekt. Zeits. 43. pp. 1329–1333, Nov. 2, and pp. 1381–1386, Nov. 16, 1922.)—The majority of the practical difficulties with respect to units originate not in the inadequacy of the known unit systems, but from two bad customs which are closely related, viz. the assumption of arbitrary unit equations and the confusion of physical magnitudes with their numerical values. The present author now points out that the remedy lies not in the search for an ideal system, but in the elimination of the bad practices outlined above. The paper contains a general discussion of units and dimensional equations. This is followed by a consideration of dependent and independent units, and of arbitrary unit equations, whereby a method is evolved for the removal of difficulties. The position of the factor 4π and the introduction of the velocity of light are then considered, leading to the derivation of general equations. The continuation of the paper deals with the numerical evaluation of the various units from the general equations, tables of values being included. H. H. Ho.

260. *The Auclair and Boyer-Guillon Accelerometers.* **A. Boyer-Guillon.** (Soc. d'Encouragement, Bull. 133. pp. 1167–1191, Nov., 1921. Rev. Gén. d'El. 12. pp. 369–370, Sept. 9, 1922.)—In this paper, the author first gives the general equation for an accelerometer, $M(\rho^2 + a^2)d\omega/dt = -\gamma a P/g + (T - P)a$, where M = mass of the movable part; P = its weight; T = tension of the spring; γ = acceleration; a = distance of the axis to the centre of gravity of the mass; ρ = radius of gyration of the mass. If the mass is kept immovable by means of an abutment, the term $d\omega/dt$ is zero; thus the first member of the equation is reduced to zero, but it is necessary to introduce into the other a term of the form $-bK$ corresponding to the reaction of this abutment. The equation then becomes $O = a\gamma P/g + (T - P)a - bK$. An instrument of this type is illustrated. The weight is supported by means of a cylindrical indicator spring on an axial rod on which it is capable of sliding vertically. This vertical rod is adjustably mounted in a supporting frame. The weight is connected on one side by means of a rigid arm to a rock shaft capable of oscillating about a horizontal axis. The opposite side of the weight is provided with a contact arm arranged above a fixed contact, or between two fixed contacts, so that a circuit is closed directly the weight begins to move; then the acceleration $\gamma = (T - t)g/P$, where T is the tension of the spring at the moment of measurement and t the tension of the spring at rest, since the term $-bK$ becomes zero. An accelerometer is then described, in which there is a central mass bearing three arms arranged 120° apart, each arm being supported on a spring and provided with an independent electric registering device, the results obtained being recorded simultaneously on a common cylinder. Another accelerometer is described, comprising a flywheel connected to its driving shaft through an adjustable spring, and provided with a similar contact device for registering. The instruments are designed for measuring the acceleration of the parts of motor vehicles. [See Abs. 1149B (1922).]

C. A.

261. *Motion of a Sphere in a Rotating Liquid.* **G. I. Taylor.** (Roy. Soc., Proc. 102. pp. 180–189, Nov., 1922.)—As referred to in previous papers [see Abs. 1361 (1921) and 715 (1922)], mathematical difficulties have so far prevented the solution of any three-dimensional problem in a rotationally moving fluid from being obtained except in the case of very slow motion, but it is shown in the present paper that a solution can be obtained for the case of the *steady* motion of a sphere along the axis of rotation of the fluid. Mathematical development of this case results in equations showing that the circulation in a ring of fluid, which is symmetrical with respect to the axis, remains constant during the motion, and that all of the infinite number of possible motions round such a sphere vanish at infinity. The case where the speed of the sphere is such that it travels a distance equal to its diameter during each revolution of the liquid is specially considered, and a diagram of stream-lines shown. In confirmation of an analytical deduction, an experiment is devised to show that when a sphere moves along the axis of a rotating fluid, it is surrounded by a sheath of fluid which does not rotate with the rest of the fluid.

A. B. C. L.

262. *Photography of Bullets in Flight.* **P. P. Quayle.** (Nature, 110. pp. 514–515, Oct. 14, 1922.)—In the method here described the setting-off or triggering of the electric spark by which the photographs are taken is controlled by the compressional wave produced by the flight of the bullet. Since the sound wave is used to trigger the photographing spark, the position of the rifle may be varied at will without affecting the functioning of the apparatus, the only requirement being that the bullet shall have a speed greater than that of sound. When this speed is less than that of sound the muzzle blast may be used to trigger the spark. In such cases the rifle must not be moved. In Prof. Boys's type of apparatus the photographing spark is set off by the closing of a secondary gap by the bullet itself. In the present apparatus a much more powerful spark may be used than would otherwise be possible, because the potential available is not limited by the dielectric strength of some trigger gap of fixed and small dimensions. When the proper potential has been attained a signal light is automatically turned on. No lens system is employed. All the photographic apparatus, except the trigger, is placed inside a small light-tight house. The trigger is located outside the house and near the trajectory. It is an interrupter of the type used by the French in connection with the Joly chronograph and consists of a metal diaphragm about two inches in diameter enclosed in a circular metal box. The diaphragm forms one side of an air-tight enclosure. On the inside face of the diaphragm is attached a circuit-breaking mechanism. This circuit-breaker functions when the crack wave emanating from the bullet strikes the diaphragm, which in turn throws back a small hammer, thus interrupting the circuit and tripping the photographing-spark-switch, with which it is connected in series. The essential parts of the photographic apparatus consist of a large Leyden jar battery charged by a motor-driven static machine, the control switch for the motor being mounted on the table with the rifle. A potential regulator, connected across the battery, functions when the proper potential has been reached and trips a switch which disconnects the battery from the charging machine and short-circuits the terminals of the latter. The switch when tripped turns on a light outside the apparatus house as a signal to the rifle operator to fire. The apparatus is provided with two light gaps, one horizontal and the other vertical, whereby a plan and an elevation of the same bullet may be taken. In obtaining photographs of a Colt automatic 25-calibre pistol the interrupter trigger was replaced by a timing device consisting of two electromagnets connected in series and adjustable in height, their function being to drop two steel balls at the same time as the key opening their circuit was depressed. One of the balls fell on a lever which pulled the trigger of the pistol. The other, released simultaneously from a greater height, impinged on a device setting off the photographing spark. By this means any reasonable lag or lead in the firing of the pistol with respect to the occurrence of the spark could be obtained. If the height of the ball which triggers the spark were changed progressively by some known amount, a series of photographs at slightly different calculable time intervals could be secured. From the data obtainable a pressure-time curve could be computed.

E. F.

263. *Note on Damped Vibrations.* **H. S. Rowell.** (Phil. Mag. 44. pp. 284–285, July, 1922.)—It is pointed out that the vibrations of bodies when resisted by a constant frictional force, say solid friction, is of great importance in practical work, and does not appear to have been adequately treated. The author solves the equation of motion, which gives a series of harmonic vibrations about centres alternating from the equilibrium position corresponding to friction being absent. The motion can be obtained by projection from a spiral which is composed of semicircles.

W. R. C.

264. *Abrasives and Polishing Powders for Glass.* **J. W. French.** (Faraday Soc., Trans. 18. pp. 42–48, Oct., 1922.)—Abrasives are required for the final form and polishing media for the final regular surface of glass; the close-grained vitreous nature of glass, and the conchoidal form of fracture are properties which enable it to be worked to its proper form and finish. The paper in question deals fairly thoroughly with the principles of the abrasion of glass, an understanding of which is essential for economical and satisfactory results. The surface cracks, and stresses resulting from percussion of a hard point, such as a steel ball, are analysed by means of polarised light, and it is shown that in the analogous case of abrasion, in which the tool (or surface) moves parallel to the surface of the glass, with abrasives between, that the rate of abrasion depends upon (1) the size of the grain, the larger grain (i.e. the coarser abrasive) giving the greater rate; (2) the force of impact which depends upon the load on the tool, its momentum, its speed of translation, and its grip on the grains; and (3) the number of impacts per unit time, the greater the speed the more frequently will each grain be brought into action. Various types of abrasive are described and illustrated, including diamond splinters, which break down into hard, sharp-cornered fragments; carborundum, which also gives sharp fragments, and which can be used with powdered or ground glass up to 60 per cent.; emery or natural alumina, which gives rounder grains and is more apt to clog; and sand, which breaks down readily and clogs.

The action of polishing is considered at some length, from the molecular viewpoint; it is mentioned that in fracture the molecules arrange themselves just as they do when the glass is acted on mechanically, or by heat, as in fire-glazing, so that the surface is continuous and free from the depressions of an abraded one. The various polishing media are discussed and some useful information is given on alternative methods of polishing to those usually employed. It is concluded from the data given that the process of polishing is a physical and not a chemical one. The question of the re-appearance of minute percussion cracks after etching polished glass is investigated and a satisfactory explanation put forward to accord with the observed facts. A. W. J.

265. *Two Properties of Powders.* **A. M. Williams.** (Faraday Soc., Trans. 18. pp. 87–90, Oct., 1922.)—In this paper the author comments on two properties of surface. It is suggested that specific surface should be referred to unit mass and not to unit volume owing to the relative difficulty of measuring the latter in the case of substances in a state of fine division. The heat of immersion is discussed and its relation to the apparent specific volume of a powder as obtained by the usual immersion method, and a new criterion is laid down to distinguish between a chemical and a physical change in certain cases. F. J. B.

266. *Breath Figures.* **T. J. Baker.** (Phil. Mag. 44. pp. 752–765, Oct., 1922.)—Cleaned glass, breathed upon, presents a uniform whitish condensation; if a blowpipe-flame has played upon the glass, the condensation on the parts played upon is more transparent and appears black by contrast (J. Aitken, Roy. Soc. Edinburgh, Proc., p. 94, 1893. Nature, May 25, June 15, July 6, 1911, Dec. 19, 1912; Vol. VII, Rayleigh's Coll. Sci. Papers). It appears probable that the effect is due to removal of a contaminating film by the flame; but the power of producing breath figures persists for a very long time. The breath figures mark also the parts where silver is first, and most cleanly, deposited. The power of producing breath figures may be communicated by contact to a cleaned plate; and this process is hastened by rise in temperature or by reduction in pressure. A. D.

267. *Technical Applications of Oscillatory Processes (Oscillation Technology).* **W. Hahnemann.** (Zeits. techn. Physik, 3. 8. pp. 265–272, and 3. 9. pp. 281–284, 1922.)—A general article on the physics of oscillatory processes, which occur particularly in electricity and in sound, but also in many other branches of physics. The first part of the paper is divided into sections dealing with closed oscillatory circuits, open oscillatory circuits, and coupled circuits. The electrical cases are illustrated by mechanical analogies with springs and masses in each case. A second section deals with the transformation of energy from one form to another during the oscillation, the factors determining the frequency of oscillation, an explanation of damping and its determination, the explanation of coupling coefficient and its determination, and the laws governing maximum reception of energy. These questions are dealt with in a simple manner (as in any good book dealing with wireless), but the problems are illustrated by reference to the mechanical case of masses and springs. A third section gives examples of the applications of oscillatory theory, with particular reference to the Frahm tanks installed in vessels to prevent rolling and to the surges of current in electrical mains, to both of which mechanical analogies are given. The author concludes by advocating the training of engineers as specialists in such problems of oscillations. B. J. L.

268. *Vibrational Responders under Compound Forcing.* **E. H. Barton** and **H. M. Browning.** (Phil. Mag. 44. pp. 573–576, Sept., 1922.)—In previous papers [Abs. 894 (1918) 621 (1919)]. Experiments have been described in which sets of responders were under double forcing, but these forces were quite independent of each other. The present paper deals with cases in which the vibrational responders in use are under forcing, either (1) from the compound harmonic motion of a single-pendulum driver, or (2) from the associated motions of two coupled pendulums. In the first case they illustrate the analysis of a musical tone by the mechanism of the ear, on the resonance theory of audition, and in the second case they show the double resonance sometimes observed when dealing with two electrical circuits closely coupled or two communicating resonating chambers used with thermophones. In case (1) the responding and driving pendulums are suspended from the same cord and the lengths of the responders adjusted so that the set of 25 forms two octaves of the chromatic scale. The compound harmonic motion of the driver is obtained by moving the bob by hand. Three photographs, giving time-exposures of the responders, show the resonance maxima when the driver has motions compounded of given frequencies. In case (2), two double-cord pendulums, each suspended by a bridle and vertical cord [see Abs. 1221 (1917)] are coupled by a bridge across the bridles. From the opposite part of the bridle of one pendulum, thirteen responders are suspended. A set of nine photographs shows the motion of the responders when the coupled pendulums are vibrating in (*a*) the quick period peculiar to the coupled system; (*b*) the slow period, and also (*c*) when quick and slow vibrations are simultaneously performed by each pendulum. Six of the photographs show the effect of varying the coupling of the driving pendulums between the limits of 10 % and 40 %. T. H.

269. *Time-Signals from the Eiffel Tower.* **B. Baillaud.** (Roy Astron. Soc., M.N. 82. pp. 491–493, June, 1922.)—These signals, from May 23, 1910, to Dec. 31, 1919, were correct (within $\frac{1}{8}$ sec.) to $\frac{1}{20}$ sec. A. D.

270. *Propagation of Explosion Waves in Gases Contained in Tubes of Varying Cross-Section.* **C. Campbell.** (Chem. Soc., J. 121 pp. 2483–2498, Nov., 1922.)—Explosion tubes, usually of glass, were joined to a length (several metres) of lead pipe of the same diameter; this lead pipe carried a sparking piece and brass tap at its further end. The flame which entered the glass tube—where it was photographed—was quite steady, in fact the detonation wave itself. The movements of the flames, which took place from left to right in the horizontal tube, were analysed on a rapidly moving wheel carrying a film moving at a known speed vertically downwards. The following conclusions were arrived at: (1) An explosion wave does not change its velocity appreciably when it passes into a narrow tube, whether this narrow tube is closed at the further end or whether it opens again into a wider tube. Very narrow glass tubes (2 mm. diameter) will allow the flame in the mixture $2H_2+3O_2$ to travel at least 40 cm. without appreciable retardation. (2) An explosion flame is suddenly retarded at any point where a sudden expansion of hot gases may occur. The retardation of a detonation wave as it passes through a flexible joint between two rigid tubes [Dixon, Abs. 1396 (1903)] is probably due to a sudden expansion at the junction. (3) The retarded flame is preceded by a compression wave, and this, after collision with the closed end of the tube, is reflected and checks the advancing flame. (4) The rates of the retarded flame and of the preceding pressure wave are dependent on the gaseous mixture, the relative sizes of the different portions of the tube, and possibly the initial pressure. T. B.

271. *Values of Sine θ and Cosine θ to* 33 *Places of Decimals for Various Values of θ Expressed in Sexagesimal Seconds.* **C. E. Van Orstrand** and **M. A. Shoultes.** (Washington Acad. Sci., J. 12. pp. 423–436, Nov. 19, 1922.)

272. *Integraph Based on Parallel Double Tongs.* **V. Karapetoff.** (Optical Soc. America, J. 6. pp. 978–984, Nov., 1922.)—This is a device for drawing a differential or integral curve to a given curve. The differential curve gives values of the slope, or rate of change, of the given curve, while the integral curve gives areas between the differential curve and its axis of abscissæ. The integraph described consists of a guide rail, along which a carriage rolls with very little friction. Two rods, movable at right angles to the guide rail, are attached, one at either end of the carriage. A cross-bar capable of rotating about a point on one rod, carries a sharp-edged wheel, which rotates on an axis perpendicular to the cross-bar, which passes through a pivoted guide carried by a bracket firmly attached to the carriage. Through this guide passes another cross-bar, which is pivoted to the other rod. One pencil is attached to one bar, and one to the other. The two cross-bars must remain parallel to each other in all positions, and this parallelism is maintained by a kinematic linkage, or parallel double tongs, consisting of two identical articulated parallelograms, pivoted together at the middle point of two identical sides. The method of drawing the required curves is carefully explained. T. C. H.

273. *Integraphs for Differential Equations.* **E. Pascal.** (Zeits. Instrumentenk. 42. pp. 232–243, Aug.; 253–277, Sept.; 300–311, Oct., and pp. 326–337, Nov., 1922.)—This is a series of mathematical papers published in successive numbers of the Zeitschrift für Instrumentenkunde, and forming a short treatise on the author's method of "Integraphs" for differential equations. The paper does not lend itself to abstraction in a concise form. The bringing to the notice of German mathematicians and German technicians of Erneste Pascal's methods was undertaken by Dr. A. Galle before the war, and interrupted until means were afforded by the journal in which they are now published.

J. J. S.

274. *The Atoms of Matter; their Size, Number, and Construction.* **F. W. Aston.** (Nature, 110. pp. 702–705, Nov. 25, 1922. Paper delivered before the Brit. Assoc., Sept., 1922.)—Attention is called to the enormous energy required to disrupt the nucleus, forming an atom of a new element (or elements), as in Rutherford's bombardment experiments. Four neutral hydrogen atoms weigh more than one helium atom, and if, as appears to be the case, the hydrogen atom consists of one proton particle and one electron, while the helium atom contains four protons and four electrons, the formation of helium implies a loss of mass; and therefore a destruction of matter and liberation of energy. If the hydrogen in a pint of water could be transmuted into helium, the energy liberated would drive the *Mauretania* to New York and back at full speed. There does not, however, seem to be much danger of a detonation of all the water in the earth, though should this happen the result would be the formation of a new star from the incandescent vaporised remains of our planet.

H. N. A.

275. *Electronic Structures of Atoms.* **M. L. Huggins.** (J. Phys. Chem. 26. pp. 601–625, Oct., 1922.)—The paper contains an account of the author's views with regard to the Lewis-Langmuir theory, which are the basis of the results obtained in previous papers [Abs. 1837, 1840, and 1843 (1922), 9 (1923), and Phys. Rev. 19. pp. 369–373 (1922)]. To account for the pairing of electrons postulated by Lewis, the author assumes a special law of force between electrons, the chief requirement for such a law being that, as two electrons approach one another, the repulsion between them is a maximum at a distance of the order 1 Å., the force then decreasing for at least a considerable proportion of the remaining distance between them. Triplets would also be possible. A number of different laws of this nature are given, and the curves representing them are plotted; but for calculating the equilibrium distances the law $f = ee'r^2/(r^4 + 1)$ is assumed. This gives 0·564 Å. as the equilibrium distance from the nucleus of lithium of each of the three extra-nuclear electrons, if these are placed symmetrically. A slight displacement of one electron towards one of the others will produce a resultant force, tending to restore it to the symmetrical position; but if it approaches the other nearer than about 0·37 Å., the resultant force tends to force them closer together; until, as a matter of fact, they are coincident. With a slightly different law complete coincidence will not result; $f = ee'(r^2 + 0{\cdot}02)/(r^4 + 1)$ gives either an equilateral triangle, with the electrons at the corners, 0·548 Å. from the nucleus; or two electrons 0·39 Å. from the nucleus, and 0·10 Å. from each other, and the third at 0·61 Å. on the other side of the nucleus. Similar results are obtained for other elements; the formation of triplets in certain cases being accounted for in a similar manner. Formulæ are worked out for the structure of the majority of the known elements, on the assumption of the existence of such pairs and triplets. The electrons and electron groups in an atomic shell are supposed to place themselves opposite the centres of the faces of the imaginary polyhedron, formed by the electron groups in the next underlying shell; and different arrangements are assigned to the electrons of the same element in compounds in which it has different valencies (cuprous and cupric copper, etc.). Periodic relationships are also simply and logically accounted for. The positions of the electrons thus described are to be considered merely as equilibrium positions, about which there may be oscillations or rotations of the electrons or electron groups. The theory is applied to explain the formation of various compounds, the building up of molecules into crystals and polymerisation.

H. N. A.

276. *Bohr's Model of the Hydrogen Molecules, and their Magnetic Susceptibility.* **K. Honda.** (Nature, 110. pp. 664–665, Nov. 18, 1922.)—According to P. Langevin's theory hydrogen molecules, formed of Bohr atoms, must be paramagnetic [Abs. 1449 (1905)]; while as a matter of fact the gas is diamagnetic. Besides three degrees of translational freedom, hydrogen molecules have two degrees of rotational freedom. According to Bohr's model the rotation must, from the point of view of symmetry, take place about an axis perpendicular to the magnetic axis of the molecule, i.e. to the line joining the two atomic nuclei. This rotation is uniform, increasing with rise of temperature. The result is that the magnetic effect due to the revolving electrons vanishes outside the molecule. Thus Langevin's theory is not applicable. A magnet is imagined, rotating about an axis perpendicular to its length, and a magnetic field acts in the plane of rotation; the magnet will be accelerated in one half revolution, and retarded in the next, and this produces a diamagnetic effect. The hydrogen molecule is such a magnet, the moment of inertia about the axis of revolution being, however, very large owing to the distance between the nuclei; and before the revolution of a molecule is sensibly accelerated, it is newly excited by thermal impacts (so that the diamagnetism is not as large as it otherwise would be). Assuming Bohr's new model, in which the electrons have elliptical orbits, the magnetic susceptibility of molecules with different orbits can be calculated. If n and n' are the azimuth and radial quantum number, and if $n + n' = 1$, the possible orbit is $n = 1$, $n = 0$, which is a circle. The susceptibility χ per gram-molecule is calculated to be $-0{\cdot}712 \times 10^{-6}$. If $n + n' = 2$, $n = n' = 1$ corresponds to the elliptic orbit, and $\chi = -5{\cdot}70 \times 10^{-6}$. The susceptibility observed by T. Soné is $-3{\cdot}96 \times 10^{-6}$, which lies between these two values. If hydrogen contains only the two kinds of molecules mentioned, 35 % of the first and 65 % of the second would give the observed susceptibility.

H. N. A.

277. *Further Studies on the Electron Theory of Solids. The Compressibilities of a Divalent Metal and of the Diamond. Electric and Thermal Conductivities of Metals.* **J. J. Thomson.** (Phil. Mag. 44. pp. 659–679, Oct., 1922.)—This paper contains a calculation of the compressibility of a divalent element, calcium, and also that of the diamond by the method given in a previous paper on the Electron Theory of Solids [Abs. 1732 (1922)]. The results obtained are in good agreement with those found by experiment. The same theory is then applied to the consideration of metallic conduction, electrical and thermal. It follows from the theory that when an individual electron is displaced relatively to its neighbours, the frequency of the vibration is that corresponding to the visible or ultraviolet part of the spectrum; these vibrations would not, unless at extremely high temperatures, absorb an appreciable amount of energy. When, however, instead of a single electron being displaced, a chain of electrons lying along one of the lines of the lattice is displaced as a rigid body relatively to the neighbouring atoms and electrons, the time of vibration of this chain may be very long, so long that even at very low temperatures the chain may acquire the full quantum of kinetic energy corresponding to one degree of freedom at its temperature. Thus chains of electrons moving like rigid bodies may travel along the lines of the lattices, and carry electricity and energy from one part of the metal to another. The theory that electric and thermal conductivity are due to the movement of these chains is worked out, and is shown to account for the variation of electrical resistance with temperature, for the super-conductivity of metals at very low temperatures discovered by Onnes, and for Wiedemann and Franz's law of the proportion between electrical and thermal conductivity.

AUTHOR.

278. *On Whittaker's Quantum Mechanism.* **H. S. Allen.** (Phys. Soc., Proc. 34. pp. 198–202, Aug., 1922.)—A brief description is given of the mechanism of E. T. Whittaker which compels all exchanges between the kinetic energy of electrons and radiant energy to conform to the quantum condition. A modified form of the mechanism is suggested, consisting of two magnetons, or two ring electrons, placed near together with their planes parallel. It is pointed out that the quantum mechanism gives the law of force postulated by Langmuir in his model of a static atom, which leads to results identical with those obtained from the circular orbits of Bohr's theory. [See Abs. 2056 (1922).] AUTHOR.

279. *The Disintegration of Elements by α-Particles.* **E. Rutherford** and **J. Chadwick.** (Phil. Mag. 44. pp. 417–432, Sept., 1922.)—The authors had previously found that long-range particles are liberated from boron, nitrogen, fluorine, sodium, aluminium, and phosphorus by bombardment with α-rays [Abs. 1445 (1921)]; and Rutherford has shown that the particles from nitrogen are deflected by a magnetic field, as if they were hydrogen nuclei [Abs. 1227 (1920)]. In the present paper experiments are described which show that the same is true for the particles from aluminium, phosphorus, and fluorine; and there seems no reason to doubt that the particles from boron and sodium are also hydrogen nuclei. The forward and backward ranges for all the above elements have been measured; and the first number after each chemical symbol in the following list is the forward range, and the second the backward range, in cm.: B 58, 38; N 40, 18; F 65, 48; Na 58, 36; Al 58, 36; P 65, 49. The forward ranges for B, F, Na, and P are subject to an error, due to the fact that powders consisting of these elements or their compounds were spread into a film, which was placed in the path of the α-rays. The particles of maximum range were produced on the surface of the powder, and had to pass through it to reach the zinc sulphide screen, with a diminution of the subsequent range in air. The remaining light elements, up to and including potassium, were carefully re-examined; none of those outside the above list were found to emit H-particles. All the active elements have odd atomic numbers in a regular sequence 5, 7, 9, 11, 13, 15. Their atomic masses are given by $4n + a$, where n is a whole number, and $a = 3$ for all the elements except nitrogen, where it is 2. Boron has two isotopes; all the others are "pure" elements. Many of the isotopes of the non-active elements have atomic masses expressed by $4n + a$, where a may be 1, 2 or 3; such isotopes may also be composed of helium and hydrogen particles; but the hydrogen must be more closely bound in the nucleus than in the active elements. The authors suggest that the fact that an element is pure may imply a certain instability in its structure; the addition or subtraction of an equal number of H-nuclei and electrons, to form isotopes, as in the case of many other elements, being impossible owing to this instability. The distribution of momentum among the three bodies involved in collision, α-particle, H-satellite, and residual nucleus, can be calculated, on certain assumptions, from the observed ranges of the expelled nuclei in the forward and reverse directions. It is found that, except for nitrogen, there is a total gain of energy in all cases, the percentage gains being B 42, N − 13, F 35, Na 6, Al 42, P 15.

H. N. A.

280. *Electron Theory of Solids.* **J. J. Thomson.** (Frank. Inst., J. 194. pp. 281–289, Sept., 1922.)—It is less laborious to calculate the properties of practically an infinite number of atoms than of a single molecule with only two or three atoms; because the average distribution of say 1, 2, 3 electrons per atom assumes simpler geometrical forms. Say a monovalent element, with one electron per atom; this may be (1) atoms at centres of cubes, one electron at each corner of each cube, or (2) atoms and electrons alternately at the corners of linear series of cubes. Assuming that the only forces in addition to those varying inversely as the square of the distances are forces varying as the inverse cube, the author has shown [see Abs. 1732 (1922)] that for case (1) the potential energy for each atom is $-(1\cdot825)e^2/d$ where d is the distance between two atoms), and in case (2) it is $-(0\cdot885)e^2/d'$ (where d' is the distance between an atom and an electron). If Δ be the density and M the mass of an atom we have $(1/d^3) = (\Delta/M)$ and $(1/d'^3) = (2\Delta/M)$. Now compress; we alter d or d', and alter the potential energy; we can thus find the energy required to produce any specific compression; and then $K = (\text{compressibility})^{-1} = (3\cdot65/9)e^2(\Delta/M)^{4/3}$ for case (1), and $(2\cdot2/9)e^2(\Delta/M)^{4/3}$ for case (2). The former, not the latter, corresponds to the compressibility data found by Richards. Similar calculations are given for divalent, trivalent and quadrivalent elements. For the surface, that surface tension $T \propto K^{3/4}$, as found by Richards, is accounted for.

A. D.

281. *Effect of Immersion Medium on Apparent Radius of a Particle.* **A. M. Williams.** (Faraday Soc., Trans. 18. pp. 53–56, Oct., 1922.)—Experiments were made to determine the size of a particle by measuring the rate of fall under gravity through a liquid, charcoal and chloroform being used. The special case of a powder which has a large internal surface equally accessible to a number of liquids was considered. The results show the necessity of allowing for the effects of adsorption in the calculation by means of Stokes' law of the radius of a particle immersed in a pure liquid.

They show how to obtain an upper limit to the thickness of the adsorption film upon a particle, and this in the case of water upon charcoal is 13×10^{-6} cm.

F. J. B.

282. *Path of an Electron in the Neighbourhood of an Atom.* **B. B. Baker.** (Phil. Mag. 44. pp. 777–786, Oct., 1922.)—Extension of

Whittaker's quantum results [Abs. 2056 (1922)] on Ewing's induced magnetism mechanism [see Abs. 1722 (1922)] to the general case where the electron is projected in any direction and passes in the neighbourhood of one of Ewing's "magnetic wheels." A. D.

283. *Nature's Architecture.* **W. H. Bragg.** (Univ. of Durham, Proc. 6. 3. pp. 117–135, 1921–1922.)—The paper contains a general review of the author's work on crystal structure. An interesting account of the shift of the molecules of diamond, to convert it into graphite, explains the lubricating properties of the latter substance. Successive sheets parallel to a natural face of diamond are moved away from one another, without altering the relative positions of atoms in the sheets. The bonds between the atoms in a sheet are as strong as ever; while each sheet is now lightly attached to the next, the distance between the two sheets being nearly doubled. Separate sheets can slide easily over one another, while the sheet formation is very persistent and the substance is flaky. If the flakes broke up easily into individual atoms the substance would be powdery, and would not lubricate. The spreading of a film of oil over the surface of water is explained by assuming that oleic or palmitic acid have a similar structure to that of naphthalene. In this substance two molecules attach themselves side by side with a little more force than end to end, the crystals growing in thin sheets and flakes. In oleic and palmitic acid there is at the end of each molecule a group of atoms which has a strong attachment for water, and this end may be supposed to "take root" easily in the surface of water. This happens to some molecules, when a drop of oil is placed on water, and other molecules come into position alongside, joining up side by side with the first, and also taking root in the water at the ends, so that a structure is formed like the fibres of a pile carpet; and growing laterally covers the whole surface of the water. H. N. A.

284. *The Crystal Structure of Phosphonium Iodide.* **R. G. Dickinson.** (Am. Chem. Soc., J. 44. pp. 1489–1497, July, 1922.)—The structure of crystals of tetragonal phosphonium iodide has been investigated by means of X-rays, using chiefly Laue photographs. It is shown that the X-ray data are satisfactorily accounted for by a structure obtained by placing in a unit of the dimensions 6·34 × 6·34 × 4·62 Å., phosphorus atoms at (000) and $(\frac{1}{2}\frac{1}{2}0)$ and iodine atoms at $(0\frac{1}{2}u)$ and $(\frac{1}{2}0\bar{u})$, where u is very close to 0·40; and it is shown that no simpler structure is capable of accounting for the data. The close relation between this structure and that of the lower temperature form of ammonium chloride is shown.

AUTHOR.

285. *The Distribution of Electrons around the Nucleus in the Sodium and Chlorine Atoms.* **W. L. Bragg, R. W. James,** and **C. H. Bosanquet.** (Phil. Mag. 44. pp. 433–449, Sept., 1922.)—Darwin's formula for the intensity of reflection of X-rays by a crystal [Abs. 1262 (1914)] makes it possible to calculate from measurements previously made by the authors [Abs. 1087 and 1773 (1921)] the amplitude of the wave scattered by a single atom, in terms of the amplitude of the incident radiation A. If this scattering is due to the electrons, and z of these are concentrated in a region the dimensions of which are small compared with the wave-length of the rays, $A'/A = ze^2/mc^2R$, where A′ is the amplitude at a distance R from the atom, in a plane containing the direction of the incident radiation, and at right angles to the electric displacement; and c is the velocity of light. The measured value tends to agree with this for small angles of scattering; but for larger angles falls below it, owing to the fact that the electrons are not packed as closely as has been assumed, with the result that the waves from the different electrons interfere. The authors endeavour to find distributions of the electrons in the sodium and chlorine atoms which give the same amplitudes for the scattered waves as those found experimentally for rock salt. It is possible to assume arbitrarily the values of a certain number of radii for successive shells of electrons, and calculate the number that would be required in each shell to produce the observed results. The method is rather arbitrary; but it gives some indication of the number of electrons to be assigned to different regions; several different assumptions lead to results of the same general nature. For the sodium atom a fit can be obtained with a shell of 7 electrons, 0·29 Å. radius, and one of 3 electrons, 0·76 Å. radius; for chlorine with three shells, 10 electrons, 0·25 Å. radius; 5 electrons, 0·86 Å.; 3 electrons, 1·46 Å. There is no trace of an outer shell of 8 electrons for either atom. The theoretical scattering due to a Bohr, ionised, sodium atom, with 10 electrons, two describing circular, one-quantum orbits; four describing two-quantum circular orbits; and four two-quantum elliptical orbits, has been found to agree with the observations. The allowance to be made for extinction of the radiation by the passage through the crystal depends on the size of the homogeneous crystals of which the crystal examined is built up. Until more knowledge of this size has been obtained the results must be regarded as provisional, as it has been necessary to assume that it is small in allowing for extinction. It is not possible to decide whether a valency electron has been transferred from one atom to the other.

H. N. A.

286. *Structure of Zinc Bromate Hexahydrate.* **R. W. G. Wyckoff.** (Am. J. Sci. 4. pp. 188–192, Sept., 1922.)—It is shown that the unit cell of sodium hydrogen acetate must contain 24 chemical molecules. The length of the side of this unit cube is found to be 15·98 Å.U. The determination of the underlying space group as probably T_h^7 defines the general manner of the arrangement of the atoms of this crystal, though it is impossible to obtain the positions of these atoms. A graphical method is outlined for identifying the planes causing the secondary spectra upon a reflection photograph.

AUTHOR.

287. *The Crystal Structure of Silver-Palladium and Silver-Gold Alloys.* **L. W. McKeehan.** (Phys. Rev. 20. pp. 424–432, Nov., 1922.)—Thin ribbons of the pure metals and of seven binary alloys of each series were prepared by fusing into small ingots and then swaging, drawing, and rolling to thicknesses of from 1/400 to 1/200 cm. The X-ray diffraction patterns were photographed by allowing the K-radiation of Mo to fall for 8 to 20 hours on each ribbon. It was found that all these metals and alloys have their atoms arranged in face-centred cubic lattices. The parameter a of each lattice, the edge of the cube, has the values $4{\cdot}08 \times 10^{-8}$, $4{\cdot}075 \times 10^{-8}$ and $3{\cdot}90 \times 10^{-8}$ cm. for pure Ag, Au, and Pd respectively. For the Ag-Pd series, the parameter is nearly a linear function of the atomic per cent. of either component and this is also true for the Ag-Au series except that for the alloys with 30, 40, and 60 per cent. Ag the values of *a* came out one per cent. too high. These results are for the most homogeneous and isotropic condition and are believed to be correct to within about 1/3 per cent. The effect of annealing at from 830° to 940° C. for an hour or more *in vacuo* was to increase the size of individual crystals, to render them more homogeneous and to make their orientations more isotropic. The effect of moderate cold working, rolling, pressing, or hammering is to reduce the size of the individual crystals and to make them less isotropic.

Densities of crystals of silver, gold, and palladium, computed from the above results of X-ray crystal analysis and the atomic weights, come out 10·49, 19·24, and 11.87 respectively. The Ag and Au were pure and the Pd contained only 0·5 per cent. impurity. AUTHOR.

288. *Crystal Structures of Potassium Chloroplatinite and of Potassium and Ammonium Chloropalladites.* **R. G. Dickinson.** (Am. Chem. Soc., J. 44. pp. 2404–2411, Nov., 1922.)—Tetragonal crystals of these salts have been investigated by X-ray methods, use being made of spectral photographs and symmetrical and unsymmetrical Laue photographs. In the simplest structure which will account for the X-ray data, each platinum or palladium atom is surrounded by four equidistant chlorine atoms lying in one plane and nearer to this platinum or palladium atom than to any other. In potassium chloroplatinite the distance from the platinum atom to a chlorine atom is 2·33 ± 0·05 Å., whilst in ammonium chloroplatinate this distance has been found by Wyckoff and Posnjak to be 2·26 Å. [Abs. 1065 (1922)]. The close relation of the structure described to that of the cubic crystals of the corresponding hexachlorides is pointed out. T. H. P.

289. *Demonstration of the Fresnel Law of Drag in Ether without Recourse to the Relativity of Time and Space.* **C. Raveau.** (Comptes Rendus, 175. pp. 613-615, Oct. 16, 1922.)—The demonstration given of Fresnel's formula [see Abs. 307 (1923)] was based on the consideration of an interference apparatus differing from that of Fizeau in that one of the interference beams traverses in reverse sense a fluid in motion and a mass of the same fluid at rest. The second beam passes through a vacuum. The apparatus is now considered both when at rest and when possessed of a velocity such that the regulation when static is preserved. The condition necessary for this is shown to be none other than Fresnel's relation. H. H. Ho.

290. *Majorana's Theory of Gravitation.* **A. S. Eddington.** (Astrophys. J. 56. pp. 71–72, July, 1922.)—The more obvious objections to these results are removed if account is taken of the relativity of the gravitational field and we suppose that the absorbing effect is zero for a freely falling body. In fact a confirmation of these results would give a direct demonstration of the principle of equivalence. Nevertheless, other very formidable difficulties arise if we attempt to construct a complete theory on this basis. If the results are correct it should be possible to construct a perpetual-motion machine. AUTHOR.

291. *The Geostrophic Approximation in the Stratosphere.* **L. F. Richardson, A. Wagner,** and **R. Dietzius.** (Roy. Meteorolog. Soc.,

J. 48. pp. 328–339; Disc., 340–341, Oct., 1922.)—The geostrophic approximation is defined as the assumption that the wind blows at right angles to the horizontal pressure gradient (γ) with a velocity $\gamma/2\omega\rho \sin\phi$. This is tested by inserting the geostrophic velocities in the equation for the accumulation of mass. A geostrophic theory of accumulation in the stratosphere has been given by L. F. Richardson resulting in the equation

$$\delta^2\theta/(\delta h\delta t) = 0\cdot288\theta \,.\, (\cot\phi/a) \,.\, (\delta v_{SN}/\delta h)$$

where a is the radius of the earth, and $\delta v_{SN}/\delta h$ is the up-gradient of the component wind velocity from south to north. A. Wagner and R. Dietzius have collected 88 pairs of observations taken between 1906 and 1914 from which the accuracy of this equation can be tested. Apart from inaccuracy in observation, it is often difficult to determine the mean values of $\delta\theta/\delta h$ and $\delta v_{SN}/\delta h$; for this reason 15 of the observations are considered doubtful. It is shown that the standard deviations of the two sides of the equation are roughly equal and that the correlation between them is probably positive when time and place vary. The correlation obtained is $+ 0\cdot07 \pm 0\cdot11$ for the 88 pairs, and $+ 0\cdot42 \pm 0\cdot11$ when the 15 less reliable are rejected. A correlation coefficient of 0·40 is found between $\delta\theta/\delta h$ and $\delta^2\theta/(\delta h\delta t)$. According to theory no correlation should exist between these, but the discrepancy may be explained either by the finite time interval involved or the occasions being selected. A. W. L.

292. *Observations of Upper Cloud Drift.* **C. K. M. Douglas.** (Roy. Meteorolog. Soc., J. 48. pp. 342–356, Oct., 1922.)—Observations of the drift of cirrus and cirro-stratus cloud have been used to determine the direction and approximate velocity of upper winds. The upper wind in cyclones is considered with reference to the temperature distribution, the motion of cirrus being shown, both for cyclones having a well-developed warm sector and for "dying" cyclones. In the former all upper winds have a large westerly component, and in the warm sector they approximate to the surface gradient wind in direction, but have a much larger velocity. In the latter case upper winds on the south side are in general the same as at the surface. The conditions required for cirrus motion of these types are shown to be in agreement with observation. Upper winds in anticyclones are discussed with reference to the thermal structure. It is suggested that the strong currents from the north-west, often observed over a developing anticyclone, will contribute to the warmth of the system and are probably necessary for further development. Examples are given of cases in which upper cloud drift may be of use in forecasting when used conjointly with the surface data. A. W. L.

293. *A Wide Angle Lens for Cloud Recording.* **W. N. Bond.** (Phil. Mag. 44. pp. 999–1001, Nov., 1922.)—The field of view of the lens described embraces a complete hemisphere, so that all the clouds, or lightning flashes, visible at the station can be recorded photographically on a single flat plate or film. Clouds at the zenith are represented at the centre of the plate, and those near the horizon in a circle round it, the distances of the images of other clouds from the centre enabling their zenith distance to be found by means of the formula $x = h\sin\theta/\sqrt{\mu^2 - \sin^2\theta}$. The lens consists of a hemisphere of glass, the horizontal plane surface of which is placed uppermost. On it rests a screen, with a small circular hole, the centre of which coincides with the centre of the sphere. The image of a distant object, above the lens, is formed on the surface of a concentric sphere, the radius of which is $r\mu/(\mu-1)$. The whole image of the sky will be sufficiently in focus on a flat horizontal plate at about $2\cdot 5r$, or rather less than $r\mu/(\mu-1)$ below the centre of the lens. A glass plate is cemented to the top of the screen and lens, which enables light incident at very oblique angles to enter the lens. The effect of chromatic aberration can be removed by using a monochromatic filter. The blurring of the zones on the plane photographic plate, which are most out of focus with an aperture in the screen $d = r/20$, is equivalent to an uncertainty in θ of about $0\cdot 25°$. H. N. A.

294. *The Drought of* **1921. F. Eredia.** (Elettrotecnica, 9. pp. 746-748, Nov. 15, 1922.)—The author discusses the possibility of forecasting a period of drought some months in advance. Attempts in this direction have not hitherto led to a practical solution of the problem. The method generally adopted is to compare the values of certain meteorological elements, and by means of correlation to deduce from the numerical values of the relative coefficients the connection, intimate or otherwise, between the given elements. Thus some have admitted and others denied the relation between droughts and sunspots, the sun being considered as the primary determinant of all meteorological phenomena. More practical results may be achieved by examining the course of such meteorological elements as are characterised by stability, and of which it is possible to forecast the ulterior direction. Such an element is the barometric pressure. From an examination of droughts in Italy it is clear that the characteristic barometric distribution is the persistence of anticyclonic areas in the Alpine and adjoining regions. Periods of high pressure coincide with dry periods. Extending our researches to the barometric conditions preceding droughts in the British Isles, it is found that persistent low pressure in the Arctic regions, and especially over Spitzbergen, points to the probable imminence of a dry period. In Italy, with persistent high pressure on the west coast of Europe, and especially on the French Atlantic seaboard, a shortage of rain is almost certain. We are thus led to consider droughts not as isolated phenomena, but as being intimately connected with the atmospheric circulation. The author concludes that we shall be better able to foresee the conditions favourable to the formation of dry periods the more extensive our knowledge of the meteorology of the northern regions, where profound modifications of barometric distribution are first revealed. E. F.

295. *Lassen Peak Volcano.* **A. L. Day.** (Frank. Inst. J. 194. pp. 569-582, Nov., 1922.)—A general account is given of the recent activity of the Lassen Peak Volcano, and a discussion of the causes. Novel features are: (1) The gradual increase in intensity and duration of the series of explosions—the last in May, 1915, being terrific. (2) There was a mud flow, accompanying the latter, which did not originate in the crater, but in a valley lower down, where considerable quantities of snow had accumulated. (3) Large areas of primeval forest were devastated partly by the mud flow, but largely by a *horizontal sand blast.* This is quite a new phenomenon in volcanology. It was due to the lifting of the volcanic plug at one edge of the crater and the sudden escape of steam and ash at high pressure from beneath it. There was evidence of the absence of chemical activity and the chemical production of heat in this eruption. The gradual increase of intensity in the series of explosions is explained by physical-chemical experiments on the crystallisation of hydrous silicate melts. It is shown that, on crystallisation, such melts give off the bulk of their water as vapour, and the pressure of the (closed) system consequently rises considerably. The gradual crystallisation of magma, which was andesitic, beneath the vent was accompanied by gradual release of water, and a continuous increase in pressure, and hence in the magnitude of the eruptions. W. A. R.

296. *Sun and Sunspots*, 1820–1920. **E. W. Maunder.** (Roy. Astron. Soc., M.N. 82. pp. 534–543, Oct., 1922. An address given on Monday evening, 1922, May 29, at the conversazione held in connection with the Centenary of the Royal Astronomical Society.)—Systematic study of sunspots began in 1826. There is only one sunspot cycle and not strictly a sunspot period. The number of sunspots ebbs and flows regularly up and down, but the latitude of each cycle begins high and diminishes, fading out near the equator. The two hemispheres are not in exact accordance, and there are indications of a difference between the east and west halves of the sun. The southern spots appear to encroach on the northern towards minimum. There is a historic instance of a period of nearly 70 years when hardly any spots were seen. The indications of the yellow pines of Arizona for this period are also abnormal, and afford strong evidence of a relation between solar activity and terrestrial weather. The rotation period of the sun is different in different latitudes. The magnetic polarity of sunspots is different in the northern and southern hemispheres. Also in the normal case of a group of spots the leader and trailer spots are also of opposite polarities. Terrestrial magnetic storms and auroræ show a marked agreement with the phases of the solar cycle, and appear to be connected with certain specific longitudes. Much information has been obtained from eclipse photographs, on one of which a ray emanating from the sun has been traced for at least six million miles. W. W. B.

297. *Theory of Astronomical Interferometer Measures.* **H. S. Jones.** (Roy. Astron. Soc., M.N. 82. pp. 513–534, Oct., 1922.)—A mathematical discussion of the subject. In the interferometer method of measuring the diameter of a circular star disc of uniform brightness, the interference fringes vanish for a separation, l, of the apertures such that α, the angular diameter of the star $= 1\cdot22\lambda/l$. If the disc is elliptical this will still hold when α is the angular diameter at right angles to the slits. If the star shows darkening towards the limb, a larger constant than $1\cdot22$ is required and can be obtained by quadratures for any particular law of darkening. If the width of the slits, a, is not small compared with l, the formula becomes $\alpha = 1\cdot22\frac{\lambda}{l}\left[1 + 0\cdot765\left(\frac{a}{l}\right)^2\right]$. In the case of a double star with components of equal size and brightness and for narrow slits, the fringes vanish at the centre of the field when $\alpha = \lambda/2l$, α in this case being the angular separation. If the apertures are wider the formula becomes $\alpha = \frac{\lambda}{2l}\left[1 + 0\cdot262\left(\frac{a}{l}\right)^2\right]$, if the observation is made on the vanishing of the central fringe. Generally, however, with poor definition, regard must be had to the visibility of the interference pattern as a whole, and the simple relation $\alpha = \lambda/2l$ must be used. A correction is required if the angular diameters are comparable with the separation. When components are of unequal size or brightness the interference pattern at the centre never quite vanishes, but the contrast becomes a minimum for $\alpha = \lambda/2l$. For measuring the angular separation of double stars the most accurate method is that of rotating apertures. If ξ be the angle between the line of centres and the direction at right angles to the slits when the central fringe changes from an oblique bright fringe to an oblique dark fringe for a small change in ξ, then $\alpha \cos \xi = \lambda/2l$, with a slight modification of conditions if the components are unequal. W. W. B.

298. *Interferometer Observations of Double Stars.* **P. W. Merrill.** (Mt. Wilson Observat. Contrib. No. 240. Astrophys. J. 56. pp. 40–52, July, 1922.)—(1) *Revised elements of the orbit of Capella* were obtained by combining the previously reported measurements of Anderson, slightly corrected, with observations made on ten nights from October, 1920, to April, 1921, using the rotating interferometer attached to the 100-inch telescope. The chief results are: $P = 104{\cdot}022$ days; $a = 0''{\cdot}05360$; $a_1 + a_2 = 126{\cdot}63 \times 10^6$ km; $\pi = 0''{\cdot}0632$; $m_1 = 4{\cdot}2\odot$; $m_2 = 3{\cdot}3\odot$. The average residuals are 1° for position angle and $0''{\cdot}0007$ for separation. (2) κ *Ursæ Majoris* was independently discovered as a double and was measured on five nights, March 1 to April 30, 1921. The separation decreased from $0''{\cdot}0836$ to $0''{\cdot}0772$, but the position angle changed only 2°. One component is brighter by, perhaps, half a magnitude. (3) ν^2 *Boötis* was found to be difficult to measure as the fringes behaved abnormally, so only a rough measurement was possible. The system may be complex. (4) *Search for New Measurable Double Stars.*—Some spectroscopic binaries, stars with composite spectra, variable stars, and some bright stars taken at random—in all 85 stars, of varying magnitude down to 5·7—were examined for duplicity, but with the exception of six doubtful cases, δ Cancri, 10 Leonis Minoris, o Leonis, ϵ and f Ursæ Majoris, and υ Sagittarii, no changes in fringe visibility with position angle of the interferometer were observed. AUTHOR.

299. *A Fifty-Foot Interferometer Telescope.* **G. E. Hale.** (Nature, 110, pp. 482–483, Oct. 7, 1922.)—Since the first measures with the 20-foot Michelson interferometer attached to the 100-inch reflector at Mt. Wilson in December, 1920, four giant stars have been measured. Provided we accept the latest values of parallax, the results are:

Star.	Diameter in Millions of Miles.
Betelgeuse	215
Arcturus	21
Aldebaran	270
Antares	400

Antares has a density only a millionth of that of water, while that of the sun is 1·4 times that of water. Obviously enormously interesting information remains to be obtained in the same way, but the 20-foot instrument is not big enough. Details are given of the design of a new 50-foot instrument which should permit the measurement of more than thirty stars brighter than the fourth magnitude and covering a wide range of spectral types. The instrument is under construction in the workshops of the Mt. Wilson observatory. W. W. B.

300. *Stellar Temperatures and Planetary Radiation.* **W. W. Coblentz.** (Nat. Acad. Sci., Proc. 8. pp. 330–333, Nov., 1922.)—In a previous paper [see Abs. 1546 (1922)] estimates of the temperatures of sixteen stars are given, based on the comparison of their spectral energy distributions with that of α Aurigæ, which is assumed to be at a temperature similar to that of the sun. This assumption is justified by the direct comparison with the sun using a vacuum thermo-couple and a series of screens transmitting narrow spectral regions. The radiation components for five regions between $0 \cdot 30$ and $10 \cdot 00\ \mu$ are obtained for the sun and α Aurigæ. The ultra-violet components of α Aurigæ are lower and the infra-red higher than the solar values. This is explained by the low emission (selective) from the sun in the infra-red. Estimates of the radiation absorbed and re-radiated by planets are also given. Such radiation is of wave-lengths between 7 and 12 μ, and is absorbed by a water cell. Radiometer measurements with and without a water cell give the amount of re-radiated energy. This is found to be: Jupiter, 0 %; Venus, 5 %; Saturn, 15 %; Mars, 30 %; and the Moon, 80 %. The intensity increases with decrease of planetary atmospheric density. Variations are noted from the polar and equatorial regions of Mars, and are attributed to absorption and cloudiness on the planet. A. W.

301. *The Galactic System.* **H. Shapley.** (Nature, 110. pp. 545–547, Oct. 21, and pp. 578–581, Oct. 28, 1922. Adapted from an address read before the British Astron. Assoc., May, 1922.)—This is largely a résumé of the author's contributions from Mt. Wilson to the study of stellar magnitudes in clusters. He regards the galaxy as a growing composite of disintegrating minor systems, and considers that evolution includes three main groups, diffuse nebulæ, stars, and spiral nebulæ, of which the second group has condensed out of the first. The third class appears distinct, as there are no spiral nebulæ in the galaxy and they do not fit into the scheme of evolution.

The great distances of globular clusters provide a very sensitive test of the degree of selective scattering of light in space. Apparently in most directions, less than one per cent. is scattered while travelling for a thousand years in space. The colour and nature of the light seems unaltered, and blue and yellow light travel with the same velocity with an uncertainty of less than one part in ten thousand million. Stellar evolution must be extremely slow, for no difference is observable between near and distant clusters, though there is a difference of 200,000 years in the age of the light received. Much has been learnt from a study of Cepheid variables, but though probably comparable among themselves, they seem to belong to a different order of evolution, and conclusions drawn from them cannot be generalised for all stars with any confidence. W. W. B.

302. *Flamsteed's Letters to Richard Towneley.* **J. L. E. Dreyer.** (Observatory, 45. pp. 280–294, Sept., 1922.)—Historical.

LIGHT.

303. *Indices of Refraction of Phosphorescent Sulphides.* **M. Curie.** (Comptes Rendus, 175. pp. 617–619, Oct. 16, 1922.)—Experimental determinations of the ratio of excitation wave-lengths to the square root of the dielectric constants in the case of phosphorescent sulphides tend to show that this ratio is not constant, as is concluded in previous work [see Abs. 1303 (1922)]. Difficulties arising from size of grain, transparency, and dispersion are discussed in relation to accuracy of determinations of the above-mentioned ratio. A. B. C. L.

304. *Refractive Index of Oxygen.* [**Miss**] **H. I. Eadie** and **J. Satterly.** (Roy. Soc. Canada, Trans. 16. pp. 63–73, 1922.)—By interferometer methods Gladstone and Dale's law was confirmed up to 40 atmos. pressure; $(n - 1)/p = 0 \cdot 192$. A. D.

305. *The Optical Properties of Molten Metals.* **A. K. Aster.** (Phys. Rev. 20. pp. 349–357, Oct., 1922.) *Bi, Pb, Sn, and Wood's Alloy to 500° and of Hg to 345° C.*—While there is considerable evidence that the optical properties of metals in the solid state do not vary with temperature, the question has not yet been investigated for molten metals. A vacuum tight furnace enabled a nitrogen atmosphere to be used so that surfaces free from oxidation could be studied. The optical properties were determined by letting plane polarised light of wave-length about 6020 Å.U. fall at an angle of 45° upon the metal surface, and analysing the reflected light with the help of a Jellet split nicol having a Brace elliptic half-shade mounted just before it. The method of calibration and use of the apparatus is described. The optical properties were found to be independent of the temperature for all the metals tried. The mean values, correct to better than one per cent., are as follows: for Bi, $\nu = 0 \cdot 493$, $k = 1 \cdot 32$; for Hg, $\nu = 0 \cdot 442$, $k = 1 \cdot 43$; for Pb, $\nu = 0 \cdot 415$, $k = 1 \cdot 76$; for Sn, $\nu = 0 \cdot 398$, $k = 1 \cdot 46$; for Wood's alloy, $\nu = 0 \cdot 397$, $k = 1 \cdot 78$. From a discussion it appears that the constancy of the optical properties is not consistent with Drude's equations. AUTHOR.

306. *Evaluation of an Integral Occurring in the Theory of Diffraction of the Solar Image by a Rectangular Slit.* **M. Hamy.** (Comptes Rendus, 175. pp. 606–608, Oct. 16, 1922.)—When the variation of brightness of the solar disc from centre to edge is taken into account, the following integral has to be evaluated, an accuracy of 0·0001 being desired:

$$\int (1 - u^2)^{(\sigma - 0 \cdot 5)} (u - a)^{-2} \cos 2m(u - a)\, du \int (1 - z^2)^{\sigma} z^{-2} \cos 2nz\sqrt{1 - u^2}\, dz,$$

where σ is a positive integer amounting to several units, m and n are large numbers, and a is positive. The transformation necessary to reduce this to a form integrable with respect to z is given. J. W. T. W.

307. *The Coefficient of Fresnel.* **C. L. R. E. Menges.** (Comptes Rendus, 175. pp. 574–577, Oct. 9, 1922.)—Fresnel's formula $c/\mu + (1 - 1/\mu)w$, gives the velocity of light in a transparent body of refractive index μ and moving with velocity w. The expression $1 - 1/\mu$, known as Fresnel's coefficient, indicates that part of the speed of the body which is added to the velocity of light. The paper gives a theoretical treatment for Zeeman's experiments on the Fizeau effect in solid bodies, and deduces thereby the Fresnel formula with the modification introduced by Lorentz, viz., $V + w = c/\mu' + (1 - 1/\mu'^2)w$, $v + w$ being the natural relativity of the motion. This formula is derived without introducing any special hypothesis, but is based on ordinary relativity considerations and the physical significance of the refractive index.

H. H. Ho.

308. *On Einstein's Aberration Experiment.* **C. V. Raman.** (Astrophys. J. 56. pp. 29–33, July, 1922.)—According to Einstein, if light from swift canal rays were focused on a slit and the transmitted rays were made parallel and were then focused on cross hairs, the image of the slit would be shifted when a plane-parallel layer of a dispersing medium, such as CS_2, is placed in the path of the parallel rays, because, due to the motion of the canal rays, the light rays on one side of the beam would have a shorter wave-length than those on the other side, and hence, if the ordinary wave theory is correct, the wave front should be rotated. It is here shown, however, that this conclusion is based on a misconception of the behaviour of such wave fronts; that the position of the final image is independent of the relative wave-lengths of the different light rays; and that, therefore, no shift is to be expected either according to the wave theory or according to any other theory of light. Hence the experiment cannot help to discriminate between the rival theories.

AUTHOR.

309. *Colour Vision and Syntony.* **E. H. Barton.** (Nature, 110. pp. 357–359, Sept. 9, 1922.)—The facts of colour vision can be explained by assuming at each element of the eye the presence of three heavily damped vibrational responders, such as may respond to light of wave-lengths rather less than $0{\cdot}76\,\mu$, about $0{\cdot}55\,\mu$, and rather more than $0{\cdot}4\,\mu$. Cases of colour-blindness would arise from absence of one or more of the responders, or from abnormalities either in respect of the frequency or of the damping. Experimental analogues described.

A. D.

310. *Early Pioneers in Physiological Optics.* **J. P. C. Southall.** (Optical Soc. America, J. 6. pp. 827–842, Oct., 1922.)—Historical.

311. *Optical Rotations of the Sugars.* I. *Aldohexoses and Aldopentoses.* **J. G. Maltby.** (Chem. Soc., J. 121. pp. 2608–2612, Nov., 1922.)—The molecular rotatory powers of the sugars appear to be governed by simple algebraic rules. By solving a series of equations the values for the successive asymmetric carbon atoms of the aldohexoses are found to be as follows:

CH_2OH .	CHOH .	CH .	CHOH .	CHOH .	CHOH
	5	**4**	**3**	**2**	**1**
	− 30°	**+ 30°**	**+ 60°**	**− 60°**	**± 84°**
		+60°	*+ 60°*	*− 60°*	*± 84°*

The corresponding values for the aldopentoses, in which the group 5 is eliminated, are shown in italics.

T. M. L.

312. *Molecular Scattering of Light.* **K. R. Ramanathan.** (Roy. Soc., Proc. 102. pp. 151–161, Nov., 1922.)—Critical opalescence, scattering of light by gases and vapours, and scattering by liquids, are in the closest relationships to each other. The author gives in this paper the results of a study made of the scattering of light in ether; in the liquid form, in the saturated vapour phases from 30° up to the critical point of 193·6°, and in the gaseous phase above the critical temperature up to 217° C. The observed results in the case of saturated ether vapour were in good agreement with the results calculated from the Einstein-Smoluchowski formula. In the case of scattering by ether above the critical temperature, taking into consideration unavoidable experimental uncertainties, the agreement again was good. There is also a satisfactory agreement in the case of liquid ether. Scattering rises rapidly as the critical point is approached, and the values for the saturated vapour, liquid, and gaseous phases approach each other and converge to a very large value at this point. The intensity of the scattering under critical conditions is about 750 times that of liquid ether at ordinary temperatures. At ordinary temperatures the light scattered by liquid ether showed an imperfect polarisation of 8 per cent. The Einstein-Smoluchowski formula is inapplicable in the *immediate neighbourhood* of the critical point.

T. C. H.

313. *The Distribution of Sensitivity and Size of Grain in Photographic Emulsions.* **E. P. Wightman, A. P. H. Trivelli,** and **S. E. Sheppard.** (Eastman Kodak Co.'s Research Lab. Comm. No. 142. Frank Inst., J. 194. pp. 485–520, Oct., 1922.)—It has recently been suggested that, at least in one and the same emulsion, "sensitivity" is nothing but an affair of geometry and probability [see Abs. 2270 (1922)]. On this view, sensitivity is only the *chance* of a grain, or connected group of grains, being hit by a light-quantum; hence, for unshadowed grains, it is strictly a matter of projective area. On the other hand, chemists and emulsion makers have arrived at a substantial theory of sensitiveness which in its most recent developments tends to identify the substances of "sensitiveness" with both the latent and the developed image, as dispersed or colloid silver. It may be assumed that in the silver bromide grain of emulsions there exists, owing to reducing conditions in preparing the emulsion, a specific, or even individual, distribution of a photocatalyst. This is very feasibly a nucleation of colloid silver amicrons dispersed in the silver halide lattice. Differential sensitivity of grains, on this view, depends upon this distribution of sensitising nuclei; any probability function found valid either for variation of sensitivity amongst grains of the same size, or relating sensitivity to size of grain, enters in the process of emulsion preparation, rather than in that of exposure. It is proposed in this and subsequent papers to examine these hypotheses, to note wherein they lead to similar conclusions, and as far as possible to test experimentally between them. In the present paper there is (1) a statement of the problem, with a discussion of some previous work on the photochemical law for the silver halide grain; (2) a correlation theory of the size frequency of photographic emulsions and their sensitometric characteristics; (3) a comparison of theories of the relation of sensitivities and size distribution to the density exposure function. The existence and nature of statistical variation of sensitivity among silver halide grains is discussed, as is also the relation of the statistical variation of sensitiveness or inertia, to the density exposure function. It is concluded that under certain conditions the first derivative of the density-exposure function will correspond with the intensity-variation function or curve. The decisive influence of the grain-size distribution and limits on the "speed" and other sensitometric variables is discussed in relation to the "quantum" and the "photocatalytic" theories of grain sensitiveness. [See also Abs. 1255 (1921).] A. E. G.

314. *Luminescence of Gases in the Electrodeless Discharge. Induction Spectra of Cæsium and Rubidium.* **L. Dunoyer.** (J. de Physique et le Radium, 3. pp. 261–292, Aug., 1922.)—It has long been known that a gas at low pressure becomes luminous when the tube in which it is contained is placed in an alternating electromagnetic field of high frequency. Such tubes have been used as detectors in researches on the propagation of electromagnetic waves used in radio-telegraphy. The authors now describe an experimental investigation of the conditions of excitation of the luminescence and of the spectra of the luminescence produced in the cases when cæsium and rubidium vapour are present in the tube. It is shown that these vapours are illuminated brilliantly at temperatures lying between 100° C. and 300° C. approximately. Certain sudden changes in the luminescence are noted, these depending on the conditions of temperature and of the electrical conditions of excitation—it being difficult to state whether the phenomena depend on the density of the vapour, or, independently, on its temperature.

The paper contains comprehensive tables of wave-length of the spectra of cæsium and rubidium luminescence. A. B. W.

315. *Absorption Bands of Cadmium.* **E. Hulthén** and **E. Bengtsson.** (Comptes Rendus, 175. pp. 423–426, Sept. 4, 1922.)—Previous experiments on mercury and zinc [Abs. 885 (1922)] are extended to cadmium, with analogous results. A. D.

316. *Ultra-Violet Absorption by Naphthalene.* **V. Henri** and **P. Steiner.** (Comptes Rendus, 175. pp. 421–423, Sept. 4, 1922.)—The hexanic solution presents 17 bands between $\lambda = 3207$ and 2563 and one for $\lambda = 2209$. The intervals are discussed and their relation to those in benzene. A. D.

317. *Intensities of the Lines in the Balmer Series of Hydrogen.* **M. Kimura** and **M. Fukuda.** (Kyoto Coll. Sci., Mem. 5. No. 2. pp. 165–168, Dec., 1921. In English.)—The authors describe a study of the influence of the vapour pressure of hydrogen, and that of the presence of chlorine, iodine, or mercury in hydrogen tubes, upon the intensities of the lines of the Balmer series. It was found that the pressure of certain amounts of the vapours in hydrogen at a small pressure reduces selectively the intensities of higher members of the lines of the Balmer series. A. B. W.

318. *Quantum Theory of the Spectrum of Hydrogen.* **H. A. Wilson.** (Astrophys. J. 56. pp. 34–39, July, 1922.)—*Energy of an Electron Moving Near a Positive Nucleus.*—It is shown that, at least when the speed of the electron is small, an appreciable fraction of the mutual energy of the two charges lies near the electron and therefore may be expected to move with the electron and modify its motion as determined by the quantum equation. Hence the influence of the field of the nucleus is probably not negligible, as is ordinarily supposed.

Quantum Theory of the Doublets of Hydrogen and of Ionised Helium.—Assuming that a fraction ($f/2$) of the mutual energy of the electron and nucleus moves with the electron, equations are derived for the energy in different orbits, which give Sommerfeld's expression for the separation of the doublets, but multiplied by the factor $(1 - f)$. Comparison of the observed separation of the hydrogen doublets (0·30) with that computed by Sommerfeld (0·365) indicates that f is about 0·2; that is, about one-tenth of the mutual energy may be moving with the electron. In the case of ionised helium, the agreement between calculation and observation indicates that f must be quite small. AUTHOR.

319. *Determination of the Wave-Lengths of* 118 *Titanium Lines by Means of the Interferometer.* **F. L. Brown.** (Astrophys. J. 56, pp. 53–70, July, 1922.)—Because of the importance of the titanium spectrum in astrophysics, a more accurate determinaion of the wave-lengths was undertaken, using a Fabry-Perot interferometer in connection with a Hilger constant deviation spectrograph. The sources of light were two water-cooled vacuum arcs, one for the titanium and the other for the cadmium lines. In order that both spectra might be photographed simultaneously an image of the Ti arc was formed, by means of a concave mirror, at the centre of the Cd arc, thus making the paths through the optical system the same for both. Two etalon separators, 9·81 and 4·99 mm. thick, were used to enable the phase correction to be determined from a comparison of the uncorrected wave-lengths obtained with the two separators, five plates being made with each. In reducing the measurements, Kilby's wave-lengths were used as a point of departure and the Cd line 6438·4696 as standard. Temperature and pressure-corrections were negligible. The results from the various plates agree on the average within 0·002 or 0·003 Å.

Interferometer measurements of the wave-lengths of 25 iron lines and two manganese lines from a vacuum arc are also included. Making allowance for the pressure-shift as given by Gale and Adams, the mean deviation from the results of Burns, Meggers, and Merrill for the iron lines is ± 0·003 Å. For the Mn lines λλ4783 and 4823, the deviation from the measurements of Goos is – 0·020 Å., perhaps a pressure-effect. AUTHOR.

320. *Arc Spectra and Ionisation Potentials in Dissociated Gases.* **K. T. Compton.** (Am. Phil. Soc., Proc. 61. 3. pp. 212–226, 1922.)—The paper describes an investigation of the ionisation potentials and arc spectra of hydrogen and nitrogen under different experimental conditions. The great complexity of spectra is due to the fact that the molecules exist in various states of association, dissociation, and ionisation, each type of molecule or atom giving rise to its own characteristic. An attempt is here made to separate the atomic from the molecular spectrum and to determine the critical ionisation potentials. It is shown that the critical potential 16·3 volts is the ionisation potential of hydrogen *molecules*, whereas 13·6 volts is that of hydrogen *atoms*. In molecular hydrogen there was no visible spectrum until the arc flashed in at or above 16·3 volts, when there appeared the Balmer series lines and part of the secondary or band spectrum. In atomic hydrogen the secondary spectrum was entirely absent, but the series spectrum appeared strongly when the arc was struck at 13·5 volts.

Similar observations were made in nitrogen, and work with iodine is in progress. A. B. W.

321. *Influence of the Presence of Gases or Vapours on the Intensities of the Lines of the Secondary Spectrum of Hydrogen.* **M. Kimura** and **M. Fukuda.** (Kyoto Coll. Sci., Mem. 5. No. 2. pp. 153–163, Dec., 1921. In English.)—The influence of the pressure of hydrogen on its secondary spectrum has been studied and two groups of lines have been identified; the one containing the lines enhanced, and the other weakened when the pressure was increased. The authors discuss the relation of these groups of lines with those classified by Fulcher and Merton.

The influence of the addition of mercury vapour or bromine to hydrogen has been examined, and has been found to have the same effect on the intensities of the lines of the secondary spectrum as that observed by simply raising the pressure of hydrogen. A. B. W.

322. *Lanthanum Violet Bands and the Associated Lines.* **J. Ôkubo.** (Tôhoku Univ., Sci. Reports, 11. pp. 95–104, May, 1922. In English). This paper describes a series of measurements of the wave-lengths of the edges of the lanthanum violet bands in a new international scale. The opinion is confirmed that each band is of double structure, and that some of them have been missed by other investigators. By means of the quantum theory, the bands are explained as due to molecular rotations caused by the line emissions, the connections being the double structure of the edges of bands necessary in consequence of the same nature of the original lines. A. B. W.

323. *Width of Certain Lines of the Spectrum of Helium as a Function of Pressure in the Source.* **L. W. Taylor.** (Astrophys. J. 56. pp. 16–28, July, 1922.)—*Visibility-Curve Photometer for Measuring the Width of Spectrum Lines.*—In the visibility-curve method, the difference of path of the two beams of light in a Michelson interferometer is increased until the visibility of the circular fringes drops to half its maximum value. To enable the visibility as a function of path difference to be determined more accurately, a comparison system of circular fringes of known and variable visibility was provided by means of a concave plate of doubly refracting crystal (selenite) placed in a beam of monochromatic plane-polarised light and viewed through a nicol prism. The two systems of fringes appeared side by side, and readings were taken by rotating the crystal plate about its axis of symmetry until both systems were equally visible. In this way line widths of from 0·03 to 0·12 Å. were measured within a few per cent.

Widths of Three Helium Lines as a Function of Pressure.—Pure helium was excited in an ordinary Plücker tube by means of a transformer. The effect of varying the power input was found to be small; in fact, multiplying the power by 4½ increased the width only 12 per cent. Also a change of capillary diameter from 1 mm. to 2 mm. did not affect the results. Using a constant power of about 9 watts, the widths of the lines λλ6678, 5876, and 5016 were measured to pressures of 12, 35, and 22 cm. respectively. Contrary to expectation, the widths do not increase quite linearly with the pressure, but approximately according to the formulæ:

$$2\text{W}(6678) = 0\cdot045 + 0\cdot0088p - 0\cdot0002p^2;$$
$$2\text{W}(5876, \text{ main component}) = 0\cdot040 + 0\cdot0034p - 0\cdot00012p^2;$$
$$2\text{W}(5016) = 0\cdot030 + 0\cdot0045p - 0\cdot0001p^2;$$

where p is in centimetres of mercury and 2W is in Ångstrom units.

AUTHOR.

324. *Visible and Infra-Red Radiation of Hydrogen.* **F. S. Brackett.** (Astrophys. J. 56. pp. 154–161, Oct., 1922.)—The radiation from the central section of a long discharge tube, such as the one used by Wood [see Abs. 1600 (1920)] to extend the Balmer series to the twentieth term, has been analysed by means of a rock-salt prism spectrometer, and readings taken with an extremely sensitive vacuum thermo-junction. Besides some unidentified lines, five members of the Paschen series, three of them new, were observed at the wave-lengths corresponding to the formula $\nu = \text{N}(1/3^2 - 1/m^2)$ where $m = 4, 5, 6, 7, 8$; also the first two members of a new series corresponding to $\nu = \text{N}(1/4^2 - 1/m^2)$ where $m = 5, 6$, were observed at $4\cdot05$ and $2\cdot63\,\mu$. According to Bohr's theory these two series are due to electrons falling from outer orbits into the third and fourth orbit respectively.

The author has also examined the variation in the relative intensity of the Balmer and Paschen series lines of hydrogen with current. For the long discharge tube used, the first Paschen line was found to increase in intensity more rapidly than H_α, as the current was increased from one-ninth to one-half an ampere through a section 7 mm. in diameter.

A. B. W.

325. *Absorption Spectrum of Potassium Vapour.* **S. Datta.** (Roy. Soc., Proc., 101. pp. 539–547, Sept. 1, 1922.)—The principal series lines in the spectrum of potassium vapour up to $m = 42$ have been observed as absorption lines and their wave-lengths accurately measured. The whole series is represented very closely by the formula, $p_1(m) = 35008\cdot40 - 109736\cdot1/(m + 1\cdot29667 - 0\cdot06154/m)^2$; except for a deviation at $m = 3$ which is somewhat abnormal, and for the last four members ($m = 39$ to 42), the agreement lies within the errors of observation, which are believed to be not greater than 0·01 A. As Sommerfeld suggested in explanation of the continuous spectrum which usually appears at the end of the series, it may be that, with these higher members of the series, when the radiating electron is knocked out of the atom, it collides with other free electrons or atoms, so that, when it falls back to the limiting orbit and forms part of the atom, the extra energy received during the collision has also to be taken into account. The first seven members of the series have been resolved into their components. In addition to the absorption of the lines of the principal series, new lines are found to be absorbed at higher pressures, these apparently showing no correspondence with the known lines in the emission spectrum. The combination lines 1s.–2d. and 1s.–3d. are found to be absorbed, the first as a pair, confirming the presence of a satellite to the lines of the diffuse series; their appearance in the

absorption spectrum gives distinct evidence of contradiction of the selection principle. T. H. P.

326. *Electric Furnace Spectrum of Iron in the Ultra-Violet, with Supplementary Data for the Blue and Violet.* **A. S. King.** (Mt. Wilson Observat. Contrib. No. 247. Astrophys. J. 56. pp. 318–339, Nov., 1922.)—This paper is supplementary in character to one published in 1913 [see Abs. 1817 (1913)]on the iron furnace spectrum from λ3884 to λ7208. Furnace emission spectra entered into the ultra-violet as far as the continuous spectrum of a black body at the same temperature. It has now been found, however, that by using a very hot source, such as a gas-filled tungsten lamp or a series of fine wires exploded by Anderson's method, absorption spectra corresponding to either low or high temperatures of the vapour may be obtained extending to λ2298, or beyond. A large number of spectrograms have been made in the first and second orders of a 15-foot concave grating. Numerous tables are given showing the temperature classification of the spectral lines. Work with various metals indicates a parallelism between the successive temperature excitation stages and the radiation stages as the potential is increased in low-voltage vacuum arcs. For high boiling-point metals, the classification can, perhaps, be more readily made by the furnace method. A. B. W.

327. *Sodium-Potassium Vapour Arc Lamp.* **F. H. Newman.** (Phil. Mag. 44. pp. 944–948, Nov., 1922.)—This lamp is made of quartz, consisting of two bulbs joined by a piece of quartz tubing. The electrodes are iron rods sealed with sealing-wax. A liquid alloy of sodium and potassium is run into one bulb, and the whole lamp is then exhausted. An electric discharge is passed through the lamp, the alloy being made the kathode. By tilting the lamp some of the alloy flows into the other bulb. Thus the quartz tube remains quite free from the alloy. The arc is struck by either tilting the lamp, or one terminal is connected to a small induction coil and a momentary discharge passed. As the temperature rises the current decreases, and the potential difference across the terminals becomes greater. With currents less than 2·5 amps. the wax seals do not soften, and there is no "browning" of the silica. T. C. H.

328. *Spontaneous Incandescence of Substances in Atomic Hydrogen Gas.* **R. W. Wood.** (Roy. Soc., Proc. 102. pp. 1–9, Oct. 2, 1922.)—The author has shown that in a very long vacuum tube, of moderate bore, at 0·5 mm. pressure, the secondary spectrum appears only at the ends; the central portion showing the Balmer series, with a faint trace of the secondary spectrum. White "infected" spots sometimes appear in the central portion of the tube, which show the secondary spectrum of hydrogen with full intensity, and these are found to be due to a contamination of the glass; a speck of stannous oxide formed by the discharge, from a minute speck of sealing-wax from a joint, produced the secondary spectrum, as did a fine wire of tungsten fused into the wall of the tube. Grinding the inner surface of the tube with carborundum produced a strong secondary spectrum; and a fractured bead of glass, introduced into the discharge tube, produced the same effect on the surface of the fracture; which shows that the ground surface in the previous case gives the secondary spectrum owing to the removal of the fine polished surface. Aluminium gives the effect at first; but ceases to do so after a few minutes;

an oxidised copper wire is also effective; but the most interesting material was thorium oxide, with a trace of cerium (fragments of a Welsbach mantle). Small specks glowed like first magnitude stars. Platinum did not show the effect at all. The surface of the active substance acts as a catalyser, causing recombination of the H atoms to form molecules. These then split up again in the electric field, producing the secondary spectrum during the explosion. Atomic hydrogen, practically free from molecular hydrogen, can be drawn by a pump from the central portion of a long vacuum tube, excited by a high-potential current; and shows its presence 4 cm. from the discharge tube by heating a tungsten wire red hot, while thoria particles were highly luminous at distances of 20 cm. or more on the interior surface of the side tube. The action of water vapour, or oxygen, in enhancing the Balmer spectrum, and suppressing the secondary spectrum, is probably due to its action on the wall of the tube which, when dry, catalyses the atomic H as fast as it is formed by the current. It may be possible to determine the optical properties (refraction, dispersion, etc.) of atomic hydrogen, by including the discharge tube in one path of an interference apparatus, illuminated by light which is passed through two apertures in a disc mounted on the shaft of a synchronous motor, in such a way that the illumination of the fringe system occurs only when the gas in the tube is non-luminous.
H. N. A.

329. *New Radiation of Short Wave-Length.* **G. Reboul.** (J. de Physique et le Radium, 3. pp. 341–361, Oct., 1922.)—In previous papers [see Abs. 556 and 2266 (1922)] the author has shown that when certain badly conducting substances are traversed by an electric current, they become the seat of emission of a very soft radiation of wave-length lying between that for X-rays and the extreme ultra-violet. The experiments now described give further support to the views previously expressed and prove that this new radiation actually exists. Results are given of the measurements of the ionisation produced by this new radiation. The substances examined were alum, rock salt, spar, gypsum, mica, quartz, and fluorine.
A. B. W.

330. *Emission of Electrons by X-Rays.* **G. Shearer.** (Phil. Mag. 44. pp. 793–808, Nov., 1922.)—The electron emission from various metals and a few salts under the influence of X-rays has been measured. It is found that the relation between the number of electrons escaping from a metal and its atomic number is very nearly a linear one. Assuming Lenard's law to hold, it is deduced that the number of electrons liberated per atom per unit time per unit intensity is proportional to the product of the number of electrons actually escaping, and the atomic weight of the substance from which they are liberated. The special electron emission associated with the characteristic X-radiations of the substances bombarded is found to be only a very small fraction of the total electron emission under the conditions of experiment. No evidence is obtained of any selective emission in the direction of the electric vector in the X-ray beam. The electron emission per unit intensity diminishes as the penetrating power of the radiation is increased. The properties of the low-speed electrons which accompany the high-speed emission were also investigated. This emission is ascribed to a secondary effect due to the action of the fast electrons.
E. A. O.

RADIO-ACTIVITY.

331. *Collisions between α-Particles and Atomic Nuclei.* **P. Auger** and **F. Perrin.** (Comptes Rendus, 175. pp. 340–343, Aug. 16, 1922.)—Experimental data obtained by C. T. R. Wilson's method. Calculations, based on Rutherford's relations and Geiger's law, give argon an atomic number 19 instead of 18. Straight portions of the track are longer and short straight tracks are fewer than probability would indicate; this may be due to the influence of deep-seated electrons. There is, in hydrogen, conservation of the kinetic energy: in other cases there is conservation of momentum. A. D.

332. *Determination of the Radium Content of Low-Grade Radium-Barium Salts.* **V. F. Hess** and **E[lizabeth] E. Damon.** (Phys. Rev. 20. pp. 59–64, July, 1922.)—Because of absorption of the rays by the salt, the present gamma-ray method is rather inaccurate for concentrations less than 10^{-5}, and for concentrations above 10^{-7} the emanation method is too sensitive. To bridge the gap, the authors have modified the first method by adopting a shallow container with two curved sides, each concentric with the cylindrical string electrometer used to measure the rays, and only a small fraction of the radius apart. This shape has the effect of making the mean absorption due to the salt small and also very nearly equal to half the maximum absorption. The procedure is to take readings with the container in position (full of the salt to be measured) first alone, then with a small radium tube of known strength placed first just in front and then just behind the container. The ratio of the first reading to the mean of the other two gives the ratio of the strength of the unknown to the sum of the strengths of the known and unknown within one per cent. The method is both quicker and more accurate than the emanation method for concentrations between 10^{-5} and 10^{-7}. The container used was made of tin plate and was 10 cm. by 10 cm. by 2 cm. thick, the radii being 30 and 32 cm. AUTHORS.

333. *Scattering of β-Rays.* **H. A. Wilson.** (Roy. Soc., Proc. 102. pp. 9–20, Oct. 2, 1922.)—Crowther and Schonland [Abs. 1320 (1922)] regard their experiments with β-rays as decisively in favour of the theory of single scattering. On Rutherford's theory of single scattering of α-rays $I/I_0 = 1 - kt$ . . . (1), where I is the number of rays deflected through less than a given angle, k being proportional to the square of the cotangent of the scattering angle ϕ. If ϕ is taken very small I/I_0 becomes large and negative, which is impossible. When I differs appreciably from I_0 the equation must be replaced by $I/I_0 = \epsilon^{-kt}$ . . . (2). J. J. Thomson's formula for multiple scattering gives

$$I/I_0 = 1 - \epsilon^{-\phi^2/kt} \quad \text{(3)}$$

Crowther and Schonland's results with β-rays do not make it possible to decide between equations (2) and (3); but they agree rather better with the latter than with the former. The author works out the deflection of an electron by a positive nucleus, on the assumption that the total energy of the electron moving with velocity v is equal to $m(1 - \beta)^{-\frac{1}{2}}$, where m is its energy when $v = 0$, and $\beta = v/c$, the electron being far from other charged bodies; but assumes that m is diminished when the electron is near the positive nucleus. The N extra-nuclear electrons of the atom are supposed to be on a sphere of radius R, round the nucleus. The colliding electron travels in a straight line, until it passes through the surface of this sphere, then in a hyperbola round the nucleus, until it passes out through the sphere R again, after which it retreats from the atom in a straight line. After a large number of such collisions $\Sigma\phi^2$ for all of them can be calculated; and even when the number is small the average value of $\Sigma\phi^2$ for a large number of β-rays will still be equal to the calculated value. For gold $\Sigma\phi^2/t = K = 228 \cdot 4\{24 \cdot 97 + 2 \cdot 30 \log_{10} R\}$. The average value of K from Crowther and Schonland's results may be taken as 683, which gives $R = 2 \cdot 2 \times 10^{-10}$, and with this value of R the modified theory of multiple scattering agrees with Crowther's and Schonland's results. This radius is probably too small; and an appreciable fraction of the electrons are probably inside most of the orbits of the β-rays. If f is the fraction of the electrons outside the orbits, R varies very rapidly with f, and is about 10^{-8} cm. when $f = 0 \cdot 65$. The modified single scattering theory, when the angles are considerable, gives a scattering smaller than that observed, though for very thin sheets the agreement with experiment is satisfactory. In earlier work by Crowther, and in more recent work by Crowther and Schonland, with larger angles, the value of $\phi/\sqrt{t_m}$ is nearly double that considered above. To explain this f must be taken nearly equal to unity. H. N. A.

334. *Some Experiments on the Penetrating γ-Radiation Present in the Atmosphere.* **E. Marsden.** (Terrest. Magn. 27. pp. 101–104, Sept., 1922.)—Measurements were made of the ionisation due to penetrating radiation, in a closed brass vessel, the inner surface of which was coated by "wiping" with old lead, containing no radio-active material. The vessel was filled with SO_2; and this combination gave about twice as great an effect from γ rays as any other metal lining and gas. Only one clear day was available, on which measurements could be made at the top of Mount Ruapehu (latitude 39°·25 S.; longitude 175°·6 E.; height 9200 ft. = 2800 metres). This is a volcanic cone, with the same kind of lava rocks from 4000 ft., where the camp was situated, to the summit. According to Kolhörster there is practically no increase in ionisation from sea level to 4000 ft. In the lead-lined vessel (vol. 9000 c.c., capacity 14·8 cm.) 18 ions per c.c. were observed at the camp before the ascent, 19 at the summit, and 18 after the ascent, at the camp. The accuracy at 9200 ft. was only a little better than 8 %, while it was rather greater at 4000 ft. From Kolhörster's result 15 ions per c.c. difference between the stations would be expected [see Abs. 888 (1914)]. The author hopes to repeat the experiment.

H. N. A.

HEAT.

335. *Specific Heat of Tungsten.* **P. F. Gaehr.** (Phys. Rev. 20. pp. 375–376, Oct., 1922.)—Suggests various possible sources of error which must be taken into account if the method of Smith and Bigler [see Abs. 1649 (1922)] is to give accurate and reliable results. J. W. T. W.

336. *Quantum Theory of Thermal Conductivity in Non-Metallic Crystals.* **Y. Endo.** (Tôhoku Univ., Sci. Reports, 11. pp. 183–193, June, 1922. In English.)—Since non-metallic crystals contain no free electrons, their thermal conductivity is attributed to atomic oscillations. Considering the oscillations of the atoms in the space lattice, the author deduces that the conductivity K is given by the relation

$$K = \frac{3nk\pi\nu Na\left(\frac{h\nu}{kT}\right)^2 e^{\frac{h\nu}{kT}}}{2\left(e^{\frac{h\nu}{kT}} - 1\right)^{3/2}}$$

where n is a numerical factor depending on the space lattice of the crystal, N the number of atoms per unit area, ν the frequency of oscillation, a the distance between two neighbouring atoms, k Boltzmann's gas constant, and h Planck's constant. Fair agreement is found between values of K obtained from this formula and experimental values for rock salt, sylvin, diamond, and fluorite. The variation of K with temperature is calculated for rock salt, sylvin, and fluorite, on the assumption that ν remains constant, and the results compared with the experimental values by Eucken. A. W. L.

337. *Vapour Pressures, Densities, and some Derived Quantities for Ether at Low Temperatures.* **R. S. Taylor** and **L. B. Smith.** (Am. Chem. Soc., J. 44. pp. 2450–2463, Nov., 1922.)—The results of the measurements here described show that the density of ether is represented by the expression $d = 0{\cdot}73629 - 0{\cdot}0011138t - 0{\cdot}000001237t^2$ for temperatures (t) between 0° and 70° and by $d = 0{\cdot}73629 - 0{\cdot}0011044t - 0{\cdot}0000004772t^2$ between 0° and − 120°. The values of the vapour pressure p in mm. of mercury at the absolute temperatures T are in agreement with the equation, $\log p = -(2168{\cdot}599/T) + 13{\cdot}882702 - 0{\cdot}01814165T + 0{\cdot}00001718195T^2$. From these results, in conjunction with the Clapeyron equation, the values for the latent heats of evaporation and for the change in internal energy on evaporation are calculated. From the latent heats thus derived the differences in saturation specific heats of the vapour and liquid are calculated, and by comparison of these with Regnault's values for the liquid, some values of the specific heat of the vapour at constant pressure are deduced. A relation between the specific volume of the liquid and the change of internal energy on evaporation is also given. T. H. P.

338. *Vapour Pressure of Lead at High Temperatures.* **C. K. Ingold.** Chem. Soc., J. 121. pp. 2419–2432, Nov., 1922.)—The vapour pressure of lead has been determined by the author at temperatures from 920° C. to 1340° C. in order to examine the applicability of vapour pressure formulæ at high temperatures. The lead was boiled under varying pressures of nitrogen in a porcelain or carbon tube inserted in a gas-fired furnace heated by a water-cooled oxy-coal gas or oxy-hydrogen blowpipe. Temperature was measured with a platinum-rhodium thermocouple standardised over the range employed by comparison with a platinum resistance thermometer, and pressure by a manometer attached to the cooler parts of the apparatus. Throughout the experiments the thermo-couple was placed at such a distance from the surface of the liquid that it would attain the temperature of the condensing vapour without superheating. The results obtained can be expressed within the accuracy of the observations by Ramsey and Young's formula $T_1/T_2 = m + nT_2$ in which T_1 and T_2 are the absolute boiling-points of two liquids under the same pressure and m and n are constants. Mercury was used for the comparison liquid, its vapour pressures being taken from the values given by Smith and Menzies. A. W. L.

339. *Cooling Power of a Stream of Viscous Fluid.* **A. H. Davis.** (Phil. Mag. 44. pp. 940–944, Nov., 1922.)—The forced convection from a hot body immersed in an infinite stream of fluid is investigated assuming that the velocity of the fluid (v_∞ at a distance from the body), is great enough for the effects of natural convection to be neglected. For a family of similar bodies, similarly orientated, and having linear dimensions L given by $v_\infty L/\nu =$ constant, it is shown that $hL/k\theta = F\left(\frac{v_\infty L}{\nu};\ \frac{v_\infty^2 t}{\nu}\right)$ provided that $c\nu/k$ is either equal to unity or is very large. When the conditions have become steady or settled down to periodic fluctuations the mean heat loss is given by $hL/k\theta = F\left(\frac{v_\infty L}{\nu}\right)$. If the value of $c\nu/k$ is not restricted $hL/k\theta = F\left(\frac{v_\infty L}{\nu};\ \frac{c\nu}{k}\right)$. It has been shown that the simpler form is fairly satisfactory for gases and that it agrees with a result for the cooling of a wire in air by Worthington and Malone. A. W. L.

340. *Natural Convective Cooling in Fluids.* **A. H. Davis.** (Phil. Mag. 44. pp. 920–940, Nov., 1922.)—The author has shown in a previous paper [see Abs. 478 (1921)] that the loss of heat by natural convection from similar bodies immersed in viscous fluid can be expressed by the relation $hL/k\theta = F(c^2gL^3a\theta/k^2)f(c\nu/k)$. Since $c\nu/k$ is practically constant for gases, the formula can be simplified by omitting this term; good agreement has been found between experimental results and the formula so simplified [see Abs. 1153 (1922)]. A theoretical investigation is given which results in the formula $hL/k\theta = F(L^3\theta gac/k\nu)$. The accuracy with which this equation may be substituted for the one given above and the form of the term involving $c\nu/k$ were determined by experiments on the cooling of wires placed horizontally in a vessel of fluid, the fluids used being toluene, carbon tetrachloride, aniline, olive oil and glycerine. The electrical energy which had to be supplied to maintain a definite difference of temperature between the wire and the fluid was obtained by measuring the current through the wire and its resistance. The effects of cooling at the ends of the wire were compensated and results were checked by measuring the fall of potential along the uncompensated portion of the wire. If d is the diameter of the wire and H the heat loss per unit length of wire per degree temperature excess, the relation between H/k and $c^2gd^3a\theta/k^2$ is shown to be practically independent of the diameter of the wire. Curves plotted between H/k and $c^2gd^3a\theta/k^2$ for different fluids form a family of approximately parallel lines with cv/k as parameter and the results show that the effect of cv/k is small. The cooling of wires in fluid can be expressed by $H/k \propto (c^2gd^3a\theta/k^2)^x(cv/k)^{-y}$ to within the limits of the experiments, where x varies from $\frac{1}{10}$ to $\frac{1}{8}$ and y varies from $\frac{1}{10}$ to $\frac{1}{8}$. If $x = y$ this gives $H/k \propto (d^3\theta gac/kv)^x$; this equation is shown to be satisfactory by plotting H/k against $(d^3\theta gac/kv)$ which gives one line for all the fluids considered. The variation of viscosity with temperature is allowed for, but temperature variations of other properties are neglected. The cooling power of the fluid may be represented by $h \propto k(ac/kv)^n$ where n varies from 0 to $\frac{1}{3}$ and thus the cooling power of a fluid is usually governed by its conductivity. A. W. L.

341. *On the Theory of Freezing Mixtures.* **A. W. Porter** and **R. E. Gibbs.** (Phil. Mag. 44. pp. 787–792, Oct., 1922.)—Guthrie's work showed that the same temperature, viz. the cryohydric, was reached for a wide range of proportions of the constituents, and that the initial temperature of the salt need not be zero, and in fact in his extreme case the salt was initially at a red heat. The object of the present paper is to consider an equation representing the heat changes which occur in a freezing mixture, and to illustrate how well it bears out the truth of Guthrie's published remarks which are quoted. The 3 possible cases are investigated, viz.: (1) Both free salt and free ice present at end of thermal change; (2) no salt remaining; (3) no ice remaining. For case 1 the final temperature must be the cryohydric and the heat equation is $T(Is_i + Ss_s) = ML_w + mL_s$, where $M =$ mass of water, $m =$ mass of salt in solutiou, $-T°$ C. = cryohydric temperature, $I =$ amount of ice, $S =$ amount of salt, s_i and $s_s =$ specific heats of ice and salt respectively, L_w and $L_s =$ latent heats of fusion of ice and of solution of salt at $-T°$ C. The general trend of results is illustrated by using constant and approximate values for which the calculations can be made easily, and it is shown that no proper proportions between the components exists, but that a range of values occurs. For case 2, S is less than 1/20th of the whole, and the equation becomes $T(Is_i + Ss_s) = ML_w + SL_s$, and as the law connecting the freezing-point with the concentration, at least for dilute solutions, is $T = 63S/M + S$, the values of T for various values of I and S can be found. These are expressed in a table. For case 3, T is found to be $= 360I/I + S$. Series of experiments were carried out to test the validity of the theory, and the results agree very well except for high concentrations of salt and even for such they are sufficiently close for confirmation purposes. The paper concludes with a note on the practical use of refrigerating mixtures and the modifications produced by the body to be cooled. H. H. Ho.

SOUND.

342. *The Frequency-Sensitivity of Normal Ears.* **H. Fletcher** and **R. L. Wegel.** (Phys. Rev. 19. pp. 553–565, June, 1922).—A more detailed account of the investigation referred to in Abs. 1164 (1922). Tests were made on 100 normal and 20 abnormal ears. W. R. C.

343. *The Resonance Theory of Audition.* **E. H. Barton.** (Nature, 110. pp. 316–319, Sept. 2, 1922.)—The facts of audition can be explained by assuming the ear to contain about a hundred vibratory responders, about twelve to the octave in the middle of the range, and each suitably damped so as neither to give too sharp a resonance nor, on the other hand, to spread the resonance too much. An illustrative working model, with pendulums, is described. A. D.

344. *Relative Sensitivity of the Ear at Different Levels of Loudness.* **D. MacKenzie.** (Phys. Rev. 20. pp. 331–348, Oct., 1922.)—To compare the loudness of two sources, the principle of a mechanically operated device called a flicker phonometer is employed in which the two sounds of different frequency alternate in the ear at a suitable rate, one being maintained constant while the other is varied from "faint" to "loud." A balance of loudness can thus be obtained. The electrical circuit, commutating relays and other apparatus used in obtaining the loudness balance are described. The currents commutated by the driven relay were amplified and supplied either to a gold-leaf thermophone or to an electromagnetic receiver which became the source of sound. Using a limited range of loudness, phonometric comparisons were made with the thermophone by ten men and ten women, for frequencies lying between 100 and 4000. The acoustic pressures P_1 and P_2 for two balanced tones, computed from the thermophone theory [Abs. No. 2016 (1922)], were found to satisfy the equation: $\log P_1 = A + B \log P_2$, which is in harmony with Fechner's law. The constants A and B are: A the sensitivity depending only on the threshold pressures, and 1/B the relative sensibility at the two frequencies. For a wider range of loudness the electromagnetic receiver was employed as the source of sound. The results agree with those obtained by the thermophone, and it is concluded that the relative sensitivity of the ear is independent of the loudness level over a wide range. [See also Abs. 1888 (1922).] G. E. A.

345. *A Photographic Study of Sound Pulses between Curved Walls and Sound Amplification by Horns.* **A. L. Foley.** (Phys. Rev. 20. pp. 505–512, Dec., 1922.)—Using the photographic method previously developed by the author, four pairs of brass plates, each of the proper section, were arranged radially about the axis of the sound-producing spark so as to provide the four passages to be studied. As the sound pulse progressed through these passages, instantaneous photographs registered its position at various stages. Six of these are reproduced. They clearly show that whenever a pulse moves at an angle to a wall there is reflection in exact accord with Huyghens's construction. Sound

pulses, therefore, do not glide around bends in tubes without appreciable reflection. In the case of a pulse emerging from the open end of a tube or horn, the per cent. of the energy reflected is small, while much of the energy of a pulse entering the large end of a conical horn is reflected back out of the end it entered. Sound amplification produced by four horn receivers of different flares and with ratios of end areas varying from 7·8 to 256 was roughly measured out of doors and also in a special room with sound-absorbing walls, using both a Rayleigh disc and a Webster phonometer. The amplifying factors found were from three to twenty times less than would be expected from the simple condenser theory, which is clearly untenable. It is concluded that the amplification is a result of both resonance and condensation.
AUTHOR.

346. *Acoustic Wave Filters.* **G. W. Stewart.** (Phys. Rev. 20. pp. 528–551, Dec., 1922.)—(1) *Theory.*—Taking the impedance of any part of an acoustic circuit to be equal to the complex ratio of the applied pressure difference to the rate of change of volume displacement, it is shown that, neglecting dissipative forces, it is possible to construct a filter having limiting frequency values of no attenuation determined by the formulæ $Z_1/Z_2 = 0$ and $Z_1/Z_2 = -4$, where Z_1 is the impedance of the transmitting conduit circuit and Z_2 of each branch of each section. The impedance of any section depends on the inertance M of dimensions mass per unit area squared, and the capacitance C which has the dimensions of stiffness per unit area squared. If M and C are in parallel, $Z = iM\omega/(1 - MC\omega^2)$, whereas if they are in series, $Z = i(M\omega - 1/C\omega)$. (2) *Construction and Test of Filters of Three Types.*—Low-frequency-pass filters were made, for example, by two concentric cylinders joined by walls equally spaced and perpendicular to the axis. Each chamber thus formed had a row of apertures in the inner cylinder which served as the transmission tube. In one case the volume of each chamber was 6·5 cm.^{3}, the radius of the inner tube 1·2 cm. the length between apertures, 1·6 cm. A chamber and one such length of the inner tube is called a section. Four such sections were found to transmit 90 per cent. of the sound from zero to approximately 3200 d.v. where the attenuation became very high, resulting in zero transmission up to about 4600 d.v. where transmission again appeared. Other similar filters of different dimensions attenuated through wider or narrower ranges. The lower limit of attenuation was found to correspond within 8 per cent. with the formula: $f = (1/\pi)(M_1C_2 + 4M_2C_2)^{-1/2}$. The upper limit was not predicted theoretically. High-frequency pass filters were made with a straight tube for transmission and short side tubes, for example, 0·5 cm. long and 0·28 cm. in diameter, opening through a hole with conductivity 0·08 into a tube 10 cm. long and 1 cm. in diameter. Six sections of such a filter would transmit about 90 per cent. of sounds above 800, but would refuse transmission to sounds of lower frequency. As would be expected, the cut off is not sharp. Single-band filters were a combination of the other two types. The agreement of each type with theory is sufficient to enable filters to be designed to fulfil set conditions. The attenuation secured with only four sections is very great, the transmission being certainly less than 10^{-7} in the attenuated region, while it may rise to 90 per cent. in unattenuated regions. Possible applications of these simple filters in laboratory work and in connection with speaking devices, are briefly suggested. AUTHOR.

347. *Musical Drums.* **R. N. Ghosh.** (Phys. Rev. 20. pp. 526–527, Dec., 1922.)—In India there are musical drums which are loaded over a central zone in such a way as to give harmonic partials. The theory is presented for two cases, namely when the load varies inversely as the first power and as the second power of the distance from the centre. It is found that in the second case the partials form a harmonic series, whereas in the first case they do not. AUTHOR.

348. *New Method for the Generation of Sound-Waves.* **J. Hartmann.** (Danske Vidensk. Selskabs., Med. 1. 13. 1919. Phys. Rev. 20. pp. 719–727, Dec., 1922. Extract.)—Pressure variation along a high-velocity air jet, produced by a pressure of 0·9 to 5 atm. above normal, was determined with a simple Pitot tube, and the periodic intervals of instability were located. It was found that these intervals of instability can be used for the generation of sound. When the small orifice to a bulb is placed in one of these intervals so that the particles of air move in and out of the opening, pulsations like those of a siren are produced, the tones not being pure. The fundamental frequency depends on the volume of the bulb, the size of the orifice, and the position in the jet, and may readily be varied from 1/10 to 5000 per second. When a simple cylindrical resonator is placed with one end in an interval of instability, pure tones are produced except in certain positions when overtones may be present. The frequency is the fundamental of the resonator and may be made as high as 125,000 per second by using a very short tube, about 0·5 mm. in length and in bore. With a hydrogen jet, the frequencies are, of course, 3·8 times as high. The efficiency of such sources is remarkable, intensities that are painful being readily produced. Practical forms of these generators are illustrated. AUTHOR.

349. *Electrical Analogue of Vocal Organs.* **J. Q. Stewart.** (Nature, 110. pp. 311–312, Sept. 2, 1922.)—It seems hitherto to have been overlooked that a functional copy of the vocal organs can be devised which depends upon the production of audio-frequency oscillations in electrical circuits. A diagram of such an apparatus is given. Periodic interruptions of the electric current, produced by a buzzer or a motor-driven current interrupter, correspond to the periodic interruptions of the air-current in the human throat by the vocal cords. The intermittent electric current thus produced excites the natural damped oscillations of the two associated resonant circuits. The oscillations of these electric currents were transformed to sound-vibrations in the air by a loosely-coupled telephone receiver. Appropriate adjustment of the two resonant circuits gave all the vowels and semi-vowels. The frequency of interruption fixed the pitch of the vowel, but did not settle which vowel was produced. The vowels thus produced were equivalent to intoned or sung vowels. If the frequency of interruption were varied suitably, these became equivalent to spoken vowels. Whispered vowels could be produced by non-periodic interruptions. Diphthongs were also producible by rapid adjustment of the resonant circuits. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

350. *Does an Accelerated Electron Necessarily Radiate Energy on the Classical Theory?* **S. R. Milner.** (Phil. Mag. 44. p. 1052, Nov., 1922.)—The author has proved that a system of two oppositely charged point electrons of Lorentz mass accelerated by a uniform electric field does not radiate [Abs. 1585 (1921)]. Professor Born has called his attention to the fact that this follows from his general theory of rigidity, and the motion of a rigid electron, on the basis of the principle of relativity [Abs. 1723 (1909)]. H. N. A.

351. *Magnetic Field and Magnetic Induction.* **E. Brylinski.** (Rev. Gén. d'Él. 12. pp. 539–541, Oct 14, 1922.)—Brylinski expresses his agreement with Langevin in the view that two physical quantities can be regarded as identical only if their respective components transform similarly, whatever the system of coordinates. On this ground he maintains the vectors B and H do not represent quantities expressible in terms of one and the same unit, and that Maxwell's equation $\mathsf{B} = \mathsf{H} + 4\pi\mathsf{I}$ should be replaced by $\mathsf{B} = \mu_0\mathsf{H} + 4\pi\mathsf{I}$. **A. Liénard's** paper (*ibid.* pp. 544–548) opens with a quotation from a French treatise, published in 1903, which he characterises as typical, which spreads the fallacy of a unique valued magnetic field existing in the interior of a magnet, that can neither be conceived nor studied except by the introduction of a small test magnet into a long, narrow cavity with the length in the direction of the magnetic axis, and noting especially the fallacious statement that the interior surface of such a cavity will be covered with a layer of magnetism which was non-existent prior to the piercing of the cavity. The author then submits the whole question to a searching mathematical investigation by widely differing methods, including those of Maxwell and of electron theory. The results obtained are as follows: (1) The consideration of the magnetic field within cavities is not essential, and if employed, they may be other than Kelvin's long, narrow, and pillbox cavities; the case of a spherical cavity is worked out. (2) Owing to the atomic constitution of the matter forming a magnet, there is no such thing as a constant value of the magnetic field within a magnet, either in space or time; mean values must be sought if definite values are desired. (3) Two distinct mean values of the magnetic field are obtained which the author calls H_1 and H_2, and these are related by the equation $\mathsf{H}_2 = \mathsf{H}_1 + 4\pi\mathsf{I}$, so that H_2 is what is called magnetic induction and is usually denoted by B, while H_1 is the H which denotes magnetic field, or magnetic force. (4) Both B and H are, therefore, special values of the magnetic field, the latter excluding, and the former including, the local contribution $4\pi\mathsf{I}$. The author expresses the opinion that while both B and H are field vectors, H is the one which it would be more appropriate to describe as *the* field vector. Larmor expressed the same opinion a good many years ago, recognising, however, that it would not be advisable to make such a change, owing to the confusion it would cause. **L. Roy**

(*ibid.* pp. 548–550), starting from the general expression for the magnetic potential, and following methods developed by Duhem and himself in their published works, arrives at the conclusion that **B** and **H** are quantities of identical nature, being of the same dimensions in every system of units, and consequently that magnetic permeability is always a merely numerical quantity. G. W. DE T.

DISCHARGE AND OSCILLATIONS.

352. *The Explosive Potential of a Gas.* **G. Holst** and **E. Oosterhuis.** (Comptes Rendus, 175. pp. 577–580, Oct. 9, 1922.)—According to Townsend's theory of ionisation by collision, the explosive potential only depends on the properties of the gas, the material of the electrodes taking no part in the process. The present paper relates to a series of experiments on the inert gases where the material of the kathode is found to exert an appreciable influence in the vicinity of the explosive potential. This observation has led the authors to assume that the positive ions do not produce ionisation by collisions against the gas molecules, but that they can liberate ions from the kathode by their electrostatic attraction. It follows that the smaller Richardson's constant is for the kathode material, the more the explosive potential will be reduced. This conclusion has been verified by experiment. The authors base a simple theory for the explosive potential upon their results. As a consequence from the theory, the kathode influence is shown to disappear for gases where the energy losses are great, and this has probably led to the original idea above. H. H. Ho.

353. *The Motion of Electrons in Carbon Dioxide.* **M. F. Skinker.** (Phil. Mag. 44. pp. 994–999, Nov., 1922.)—The method used is described in papers by Townsend and Bailey [Abs. 970 and 1685 (1922)]. The electrode E_2 was not exactly under the slit, but was 0·6 mm. to the right. Tables and curves are given showing the relations between the pressure p, the field z through which the electrons travel, the factor by which the kinetic energy of the electron exceeds the kinetic energy of a molecule of a gas at 15° C., the velocity of the electrons in the direction of the electric force w, the velocity of agitation of the electrons u, their mean free path and the proportion of the energy lost in collision with a molecule. No permanent ions were formed in the gas. Curves are given showing the relations between w and z/p for CO_2, H_2, and N_2. With values of z/p greater than 30 the loss of energy in a collision is comparatively large; so that the velocity of agitation is less than seven times w. For the higher values of z/p the mean free path increases with decrease of u, but for the lower values it decreases with decrease of u. There is a remarkable increase in the loss of energy of an electron in a collision for comparatively small increases in u from 13×10^7 cm. per sec. to 15×10^7 cm. per sec. H. N. A.

354. *The Motion of Electrons in Argon and in Hydrogen.* **J. S. Townsend** and **V. A. Bailey.** (Phil. Mag. 44. pp. 1033–1052, Nov., 1922.)—Previous experiments by the authors have shown remarkable differences between the motion of electrons in argon and in nitrogen or hydrogen; and in the present investigation the determination of the velocities has been extended over larger ranges of pressures and forces.

Electrons were liberated from a copper plate by the action of ultraviolet light, and passed through a charged wire gauge and a slit in a plate at a lower potential, to three electrodes mounted on plate glass, fixed to a guard ring kept at zero potential. The centre line of the central electrode did not lie exactly in the line of the stream of electrons through the slit; and by applying a suitable magnetic field the stream could be diverted, so as to fall on the dividing line between the central electrode E_2 and that to the left of it, E_1; or on that between E_2 and E_3 to the right. It could also be brought to the centre of E_2, in which case the current received from E_1 was equal to that from E_3. By this means the velocity w of the electrons moving through the electrostatic field z was found. By determining the ratio $R = n_2/(n_1 + n_2 + n_3)$ of the charge n_2 received by the central electrode E_2 to the sum of the charges for the three electrodes, it was possible to find u the velocity of agitation of the electrons. For small values of z/p, where p is the pressure in the apparatus, w is smaller for pure argon than for hydrogen, while for larger values it is larger. When moving with a velocity of agitation $u = 12 \cdot 6 \times 10^7$ cm. per sec. the fraction of its energy lost by an electron in a collision with an argon molecule is $\lambda = 1 \cdot 6 \times 10^{-5}$, while it is 5×10^{-2} in N and 4×10^{-2} in H. For large values of z/p, in argon, u becomes approximately constant near 20×10^7 cm. per sec., λ rising from $2 \cdot 38 \times 10^{-5}$ for $u = 19 \cdot 3$ to $38 \cdot 6$ for $u = 20 \cdot 7$. This large increase is ascribed to a large loss of energy in collisions with velocities greater than the mean, and a change in the distribution about the mean as z and w increase. The mean free paths of the electrons, as determined from these experiments, are much longer in argon than in nitrogen or hydrogen. With $u = 12 \cdot 6 \times 10^7$ cm. per sec., the values of l are $0 \cdot 147$ cm. in A, $0 \cdot 029$ cm. in N, and $0 \cdot 035$ cm. in H at 1 mm. pressure. If the molecules were elastic spheres, of the radius σ obtained from the viscosity of argon, the mean free path would be $0 \cdot 0286$ cm. Experiments with mixtures of A and H give the free paths in argon for smaller values of u, the maximum value being $1 \cdot 61$ cm., when $u = 3 \cdot 64 \times 10^7$ cm. per sec. H. N. A.

355. *Thermal Ionisation of Gaseous Elements at High Temperatures. A Confirmation of the Saha Theory.* **A. A. Noyes** and **H. A. Wilson.** (Nat. Acad. Sci., Proc. 8. pp. 303–307, Oct., 1922. Am. Chem. Soc., J. 44. pp. 2806–2815, Dec., 1922.)—The degree of dissociation of the first electrons from atoms of a number of elements at different temperatures and pressures has been calculated by Saha from the ionisation potential of the element by employing the ordinary thermodynamic expression for the effect of temperature on the equilibrium of chemical reactions, or $\log K = \frac{-\Delta H_0}{RT} + \frac{\Delta C_p}{R} \log T + \frac{I}{R}$. The heat of ionisation or $\Delta H_0 = N\epsilon V = 96500V$, where V is the ionisation potential. ΔC_p, the increase in heat capacity at constant pressure is determined by the value for the electron gas and is assumed to be equal to that of monatomic gases generally, i.e. $2 \cdot 5$ R per mol. The integration constant I is deduced from theoretical principles which apply to ordinary monatomic gases.

It is pointed out in the present paper that a computation of the relative magnitudes of the ionisation constants may also be made from the measurements of H. A. Wilson on the electrical conductivity of flames into which salt solutions are sprayed. Absolute values are obtained from the conductance data by using values for the mobilities of the electrons and the number present per c.c. in similar flames free from salt. The conductance of the flame is found to be independent of the acidic constituent of the salt, which indicates that a chemical breakdown of the salt occurs and that conductance is due to the ionisation of the metallic element. The conductance changes with the concentration of any given salt as required by the equation

$$\frac{pM^0 + pE'}{pM} = K = \frac{x^2p}{1-x}$$

where K is the equilibrium or ionisation constant, p the total pressure, and x the portion ionised. For different elements of the alkali group, the values of K calculated from flame conductances are closely parallel to those derived from ionisation potentials. The values found for these constants explain the disappearance, in astrophysical observations, of the lines of certain elements in solar prominences where, at the extremely low pressures and high temperatures prevailing, complete ionisation occurs, thus eliminating lines given by the neutral atom. [See Abs. 682 (1921).] J. N. P.

356. *Bombardment of Metal Surfaces by Slow-Moving Electrons.* **H. E. Farnsworth.** (Phys. Rev. 20. pp. 358–374, Oct., 1922.)—A brief summary of previous work on secondary electrons produced by electronic bombardment of metallic surfaces is given and it is pointed out that the important characteristics of this problem still remain unsolved. It is necessary to know (1) the magnitude of the secondary electron current as a function of the primary velocity, (2) the velocity distribution of the secondary electrons for any given primary velocity. The primary stream was produced from an equipotential platinum kathode coated with barium, strontium or calcium, and heated by radiation from a tungsten spiral filament. This stream passed through a series of limiting diaphragms into a long Faraday cylinder so that the total primary current could be measured. The target (only a nickel target was employed in the present investigation) could be interposed in front of this cylinder, intercepting the primary beam, which was then received on a second cylinder. The two cylinders were separated by an insulated diaphragm ; and by the application of a varying retarding potential between this diaphragm and either cylinder the velocity distribution of the electron stream could be determined. The vacuum was 10^{-7} mm. The ratio of the secondary to the primary electron current was found to be independent of the roughness of the surface, but depended on treatment. Heating to a bright red heat *in vacuo* changed the shape of the secondary electron curve and decreased the magnitude of the secondary electron current. Exposing the surface to hydrogen increased the secondary electron current. A sudden change in the shape of the secondary electron curve occurs at about 9 volts' primary velocity, which together with a difference in the velocity distribution of the secondary electrons for primary velocities below and above 9 volts suggests that emission or ionisation at the surface begins at this voltage and increases with primary velocity ; and that between 0 and 9 volts only reflection occurs. The presence of secondary electrons with velocities nearly equal to that of the primary beam for the higher velocities suggests that reflection continues after emission begins. L. L.

357. *Initial Electric Tensions between Spherical Electrodes in a Cylindrical Enclosure.* **M. Toepler.** (Zeits. techn. Physik, 3. 10. pp. 327–332, 1922.)—This paper continues an earlier investigation [see Abs. 1271B (1907)] of the initial electric tensions between freely placed spherical electrodes, when the influence of the environment is taken into account. Measurements are now described when the spherical electrodes are enclosed within 4 different types of cylindrical cage earth-connected. Copious tables of results are included. H. H. Ho.

358. *Discharge Figures.* **U. Yoshida** and **S. Tanaka.** (Kyoto Coll. Sci., Mem. 5. No. 2. pp. 145–152, Dec., 1921. In English.)—A discussion of positive and negative discharges as shown on photographic plates under various conditions. Illustrations of the discharges referred to. **S. Tanaka.** (*Ibid.* pp. 201–204, Feb., 1922.)—Discussion of various modifications of Mikola's experiment [Abs. 666 (1917)]. A. D.

359. *Crookes's Radiometer.* **J. Satterly.** (Roy. Soc. Canada, Trans. 16. pp. 75–81, 1922.)—When Crookes's radiometer is used to measure the radiation at different distances D from a red-hot iron ball the graph (absc. = revs. per min., ord. = D^{-2}) is practically straight and passes through the origin except for speeds less than 5 to 7 revs. per min. Below this the revs. per min. fall off more rapidly than the intensity. For the cooling curve of a red-hot ball, decrease in revs. per min. is proportional to decrease in the intensity of the radiation, so long as the radiometer continues to revolve; but unless the radiometer be close to the ball, revolutions cease at a comparatively early stage of the experiment. A. D.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

360. *The Voltage-Current Relation in Central Anode Photo-Electric Cells.* **H. E. Ives** and **T. C. Fry.** (Astrophys. J. 56. pp. 1–15, July, 1922.)—*Effect of Frequency of the Exciting Radiation.*—In the case of some potassium cells it was observed that the higher the frequency of the light the higher the voltage required for saturation. The mathematical theory was then developed for the case of a spherical anode of radius b at the centre of a spherical kathode of radius a. Electrons emitted from a photo-sensitive spot on the kathode describe elliptic orbits determined in each case by the initial direction and velocity and by the electric field. If the maximum velocity of emission of the electrons for radiation of frequency ν is v_m, where $\frac{1}{2}m_m^2 = h(\nu - \nu_0)$, the minimum difference of potential for saturation comes out as $V_s = h(\nu - \nu_0)(a^2 - b^2)/eb^2$. Assuming that the distribution as to direction follows the cosine law, and that the distribution as to energy follows a parabolic law with a maximum at half the limit set by the quantum relation $\frac{1}{2}mv_m^2 = h(\nu - \nu_0)$, then the fraction of saturation for any voltage below V_s is $1 - \left\{(a^2 - b^2)/a^2\right\}\left\{1 - V/V_s\right\}^3$. For an assumed case of $a/b = 15$ and $\nu_0 = 5 \times 10^{14}$ (6000 Å.), V_s comes out 40 and 160 volts for radiations of wave-length 5500 Å. and 4500 Å. respectively. These differences agree as to order of magnitude with some experimental observations. This effect should evidently be taken into consideration whenever such cells are used to compare the intensities of radiations of different spectral distributions. AUTHORS.

361. *Thermo-Electric Force, the Entropy of Electrons, and the Specific Heat of Metals at High Temperatures.* **W. M. Latimer.** (Am. Chem. Soc., J. 44. pp. 2136–2148, Oct., 1922.)—The thermo-electric force of a circuit of two metals is expressed in terms of the entropy of the electrons in the two metals. On the postulate that the specific heat of a mol of electrons in a metal is given by the increase in the specific heat at constant volume above the equipartition value $6(\frac{1}{2}R)$, the absolute value of the thermo-electric force of the K-Na couple is calculated from the specific heats of K and Na. Various thermo-electric forces are calculated and plotted out. Entropy of metal electrons at low temperatures is discussed, and values of c_v deduced from thermo-electric data. A. D.

362. *The Thermo-Electromotive Force of Copper-Manganese Alloys.* **S. Kimura** and **Z. Isawa.** (Phys. Rev. 20. pp. 441–451, Nov., 1922.)—The alloys (copper with 5 to 23 per cent. manganese, were prepared from electrolytic copper and thermite manganese, but contained as impurity about one-fiftieth as much iron as manganese. The alloys were cast and then drawn to fine wires. After they had been annealed at 200° C. for 8 hours, the thermo-electromotive forces against fine pure copper wire were determined for various temperatures of the hot junction up to 100° C. The curves, as usual, correspond to the equation $E = \alpha t + \beta t^2$. For $t = 100°$ C., E is positive for all the alloys, especially if allowance is made for the effect of the iron content, though practically zero for alloys with less than 10 per cent. Mn. The alloys as cast and as drawn were more positive than after annealing. However, E showed negative values for the lower manganese alloys and for the lower temperatures, especially when the iron content was increased. In fact, though α is probably positive for all pure Cu-Mn alloys, the effect of small percentages of iron, carefully studied to 2 per cent. with a series of 30 alloys, was to decrease α so that for 13 per cent. Mn and more than 0·50 per cent. Fe and for less than 11 per cent. Mn and more than 0·20 per cent. Fe, α is negative. On the other hand, β is always positive, but tends to decrease as the percentage of Mn is increased. Two alloys indicated that the effect of 2 per cent. nickel is to decrease α nearly as much as an equal amount of iron. The effect of aluminium seems to be the reverse but the five alloys tested did not give consistent results. Ordinary manganese contains just enough iron as impurity to make its E slightly negative at ordinary temperatures, but adding 1 per cent. more iron, as suggested by Hunter and Bacon, would lower it too much. The electron theory of thermo-electromotive force is discussed. AUTHORS.

363. *Self-Inductance of a Circular Coil of Rectangular Section.* **H. Hemmeter.** (Archiv f. Elektrot. 11. pp. 155–182, Aug. 20, 1922.)—The author's objective is to obtain a general solution or a practicable scheme by means of which the self-inductance of any circular coil of rectangular section may be calculated with sufficiently close approximation for any practical purpose. The attempts to achieve this object are all based essentially on Maxwell's method of first obtaining: (1) A general formula in which the section of the wire is taken to be rectangular; each layer, generally parallel to the plane of the coil, is assumed to be exactly so, and therefore to lie in a plane, and the space occupied by the insulation and that left unoccupied owing to the actual helical winding are regarded as negligible: (2) A corrective formula taking account of the circularity of the wire and the other departures from the ideal form (1). These attempts now form an extensive literature which has been examined by the author, with the result that he finds none fulfilling the requirements which he specifies except for special cases. Two solutions, Stefan's formula, published in 1883, and Weinstein's, in 1884, he finds to stand out beyond all others. Both are very complex, as was that of Maxwell; both of very different type and yet leading to nearly identical results; and both, unfortunately, simply stated without any indication of the way in which they were obtained, probably on account of the immense amount of calculation involved. Stefan's formula was selected as a most suitable starting-point for his own work, which has necessarily been most laborious, the formula being derived by the fourfold integration of an infinite series. The ideal coil may be specified by the mean diameter $2a$ of the circular ring together with the axial width b and the radial depth c of the rectangular space it occupies. The author found that Stefan's formula for the self-inductance of the ideal coil only holds good provided b be not less than c, and that when b is less than c a modification is required. When so modified, Stefan's formula was found to give at least as good a solution as any of the special formulæ, such as those obtained by Strasser and Esau, for coils with very few turns, i.e. in which b or c, or both, were small. The mathematical difficulty in developing Stefan's formula is confined to the terms of the second degree, and the author avoided this difficulty by devising a method of approximation. The remainder of the calculations have been verified now by a good many workers. The author finds that for coils with any number of windings, from two up to the dimensions determined by the conditions $b/2a = c/2a = 0{\cdot}6$, the error, without applying any of the corrections previously enumerated, is less than 1·3 %, and decreases rapidly with decreasing dimensions; when the corrections are applied the error of 1·3 % is reduced to 0·5 %. The author is continuing the calculations, and is satisfied that the error can be reduced to the above amount of 0·5 %, even for coils of the largest dimensions. He expresses his intention of publishing tables which will make it easy to calculate the self-inductance of any coil of the type considered with an error not exceeding this very small percentage. G. W. DE T.

364. *An Electron Theory of Electric Conduction in Metals.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 8. pp. 307–313, Oct., 1922.)—The present communication is a modification and extension of the dual conception of conduction set forth in a previous paper [see Abs. 404 (1917)]. It commences with a discussion of the behaviour of ions in conduction followed by that of Ohm's law, the temperature relation, and the behaviour of the free electrons in conduction. The author has been led to the conclusion that the diameter of the outer electron shell of an atom may be as small as one-half the mean centre to centre distance of neighbouring atoms. The impressed electric field is held to do its work, under ordinary conditions, by turning the ions so that the pits upon them (from which the electrons have been dislodged), wherever they at first occur, move as a positive charge would move, in the conventional direction of the field force, while the electron portion of the damaged surface shell of the ion moves as a whole in the opposite direction. Thus an electric current occurs and the effect of the to-and-fro heat translations of the ion, superposed on the process of orientation, seems to be, practically, to enlarge the ion. The paper itself is written in summary form without extended argument and should be consulted in its entirety. H. H. Ho.

365. *Contact Resistances, Especially at Carbon Contacts.* **R. Holm.** (Zeits. techn. Physik, 3. 9. pp. 290–294; 3. 10. pp. 320–327, and 3. 11. pp. 349–357, 1922.)—This investigation concerns microphone effects, and the paper commences (1) with a reference to previous work by Abbott, Wietlisbach, Bidwell, and Pedersen [see Abs. 324B (1916)]. The subject is then considered in the following sections: (2) theory of the contact resistance; (3) theory of the dependence of contact resistance on current density; (4) methods of measurement; (5) properties of material; (6) measurements with single grains between plates using a weak current; (7) measurements at different contacts with a weak current; (8) comparison of the measurements; (9) results with several layers of grains; (10) the dependence of contact resistance on current; (11) microscopic observations at carbon contacts; (12) the influence of the surrounding medium (air, other gases, or *vacuo*) and its pressure on the carbon contact resistance; (13) the pressure coefficient of the electrical conductivity of carbon; (14) experiments with an oscillator; (15) the detector theory; (16) a non-conducting layer in the contacts and the dimensions of the πa^2-surfaces; (17) summary of results. The fundamental assumption is made that the contact resistances are such that a current passes through a sieve of small conducting contact surfaces (πa^2) which constitute a small part of the microscopic touching surfaces, and for contact are pressed together. From this standpoint formulæ are derived for the resistance and its dependence on current strength. It is assumed that the Joule effect partly influences the conductivity of the contact material, and partly increases the metallic conducting contact surfaces. The formulæ were experimentally confirmed. The relation between resistance $\bar{M}$ and load P at a contact is given by $\bar{M} = \bar{M}_0 P^{-\alpha}$, where for small pressures $\alpha = 1$, but at higher pressures $\alpha < 1$. The data obtained support the thermoelectric theory of contact detectors in certain respects. The effect of the Rohmann layer is to complicate greatly the behaviour of contact resistances. Earlier observers have considered too few variables. The paper is amply illustrated by diagrams and tables of data. H. H. Ho.

366. *Tungsten Furnace for Experiments on Dissociation and Ionisation.* **K. T. Compton.** (Optical Soc. America, J. 6. pp. 910–912, Oct., 1922.)—A tungsten tube furnace is described, made of thin tungsten sheet bent in the form of a cylindrical tube and clamped by end pieces. The end pieces consist of a small steel " napkin ring " fitting into a split rectangular steel block. The blocks are mounted on water-cooled brass tubes, which serve as leads for the current. A central electrode, consisting of a 20 mil tungsten wire, welded to heavier molybdenum leads, serves to secure an equal potential drop along the furnace and filament. The furnace required about 100 amperes at 6 volts to reach a good white heat. It is suitable for studying low-voltage arcs and has been used to investigate conditions of spectral excitation. F. J. B.

367. *The Earth Inductor Compass.* **P. R. Heyl** and **L. J. Briggs.** (Am. Phil. Soc., Proc. 61. 1. pp. 15–32, 1922.)—The principal defects of the magnetic type of fluid compass in general use on present-day aircraft are due to the fixed and variable disturbing effects, due in turn to fixed magnetic parts or variable ones in the aircraft itself. Moreover, the proximity of electrical circuits such as wireless ones, and the magneto, often results in the compass coming within their magnetic fields and giving false readings. Another serious defect is that due to the compass needle having a period of its own, which frequently synchronises with that of the aircraft, whilst the effect of the displacement of the plane of rotation of the needle from the horizontal brings it within the influence of the earth's vertical field and causes the well-known northerly turning error. An attempt is made in the earth inductor type to obviate the errors inherent in the magnetic type, and the present paper describes an instrument of the former type which has been tested in position on an aeroplane. The method employed consists in rotating about a vertical axis, by means of a cup-type windmill, an armature with a soft-iron core, and using a commutator with four collecting brushes spaced at 90° to take off current. A null method is used for indication, such that the pilot after setting his course, by means of a course-setting device, steers so as to keep the galvanometer needle central; means are provided to enable the given course indication to be distinguished from the opposite direction. A method is also provided for eliminating the errors due to rolling and pitching arising from the earth's vertical field. The mathematics of the armature connections and the course-setting device are dealt with at some length, and the construction, in detail, is given of a successful experimental instrument. The results of tests made in the air indicate an accuracy of reading, during rolling or pitching of 2½ degrees, and a damping out of the effects of centrifugal action and banking in about 3 secs. after levelling up. The experimental compass has run for 146 hours with a variation of less than 1 degree due to mechanical or electrical defects, and it is anticipated that the final design of this compass will outlast the aircraft, from the endurance point of view. A. W. J.

368. *Construction of Platinum Thermometers and of Resistance Coils.* **J. R. Roebuck.** (Optical Soc. America, J. 6. pp. 865–874, Oct., 1922.)—Zero alterations of platinum thermometers may be caused by variation of resistance due to gradual relief from mechanical strain and other causes. A form of thermometer coil is described, which avoids strain during use, and makes thorough annealing possible. A cylinder is constructed with a central rod of metal and metal end pieces, carrying four strips of mica, which run edgewise between them. The spaces between the strips are filled in with fairly hard wax, so as to complete the cylindrical surface, and on this a fine double thread is cut which makes notches on the edges of the mica sheets. The thermometer wire is then annealed, wound on the cylinder, and connected to the leads; the wax is removed by a suitable solvent and the coil annealed by heating it gradually inside a hard glass tube, which prevents the wires from getting out of place. While it is hot a small current will make the wire incandescent and complete the annealing. The coil now forms a perfect spiral, with no sudden bends at the points of support, and no possibility of strains due to changes of temperature. The zero of such a coil has been found to be very steady. The large amount of metal used in the construction increases the heat capacity and so makes the lag larger. In many cases this is not important, and steadiness of the zero is always very desirable. In constructing the resistance coils a somewhat different method is employed, as manganin wire is very stiff, and it is desirable to use a coarse wire to diminish the change of resistance due to surface oxidation. Four grooves are milled out of a brass cylinder, so that the section is cross shaped. They are filled with paraffin wax, and four strips of mica are laid along the cylinder, one along each of the edges of the cross. The strips are tied down with string or wire, so as nearly to cover the surface of the cylinder, small gaps being left between the edges of adjacent strips. The resistance wire is then wound on and connected to the terminals, the wax removed, and the wire annealed. It is best to enclose each coil in a container with acid-free, dry kerosene. H. N. A.

369. *A Simple Direct-Reading Potentiometer for Standard Cell Comparisons.* **M. Eppley** and **W. R. Gray.** (Optical Soc. America, J. 6. pp. 859–864, Oct., 1922.)—The slide-wire type of potentiometer has the disadvantage that the resistance may vary along the length of the wire, while the Feussner potentiometer is expensive, owing to the large number of coils required. The instrument described is intended solely for comparing cells with a standard cell; so that a minimum number of coils and contacts is required. The standard cell is connected to the two required points in the circuit by means of plugs, attached to flexible leads, and fitting into conical holes in the contact pieces, between which the steps of resistance are connected. Two sliding contacts, working over these, make possible the connection of the cell which is being measured to suitable points of the circuit. A double-pole, two-way switch puts the galvanometer in the circuit of the standard cell or of that which is being compared with it. H. N. A.

370. *Electron Tube Tuning-Fork Drive.* **E. A. Eckhardt, J. C. Karcher,** and **M. Keiser.** (Optical Soc. America, J. 6. pp. 949–957, Nov., 1922.)—The electron tube drive has been applied to a large number of forks in the frequency range from 50 to 2000 cycles. The electron tube circuit generally consists of a plate or power circuit and a grid or control circuit, both being completed through the electron tube and having common circuit elements therein. The circuits may be coupled externally, so that the total action becomes regenerative, as, for example, when the current rise in the plate is followed by a potential rise of the grid. A current thus generated is oscillatory. In the authors' apparatus the closing of the plate circuit starts the plate current through the driving electromagnet. The fork prongs are pulled together and vibrate feebly, but this has a relatively large effect on the reluctance of the magnetic circuit, the changes of which are in synchronism with the free period of the fork. Corresponding variations in the plate current result which are regeneratively amplified, causing the fork to vibrate with progressively greater amplitudes until limited by the properties of the tube. A mica condenser is connected across the grid coil for tuning purposes. If the adjustment of the filament current is sufficiently close so that the beats between the two frequencies of the fork as the free period is approached are slow, the beat period will automatically increase until the beats disappear, and the circuit will be completely controlled by the fork. T. C. H.

371. *Registering Electrical Contacts with a Triode Valve.* **G. A. Tomlinson.** (Phil. Mag. 44. pp. 870–872, Nov., 1922.)—In the case of a relay causing a feeble movement of one instrument to make a contact and close the circuit of a second comparatively powerful instrument, supplied from an independent source, a three-electrode valve can be used with advantage. A small tongue of platinum is moved by the first instrument between two platinum points and on making contact either raises or lowers the potential of the grid by about 4 volts, by means of batteries. The reaction in the anode current operates the second instrument. The actual values of the grid potential vary between − 2 and + 6 volts. Resistances in the circuit enable a fine adjustment of the platinum points by micrometer screws to be made. The advantages of such a relay are: (1) Very small current transmitted through the contacts; (2) variation in the resistance of the contact within wide limits has no effect on the action; (3) amplification of mechanical power is provided for by the valve; (4) the relay can be operated by much weaker forces than the ordinary relay. T. C. H.

372. *Testing of the E.M.F. of the International Weston Element by Means of the Silver Voltameter.* **H. v. Steinwehr** and **A. Schulze.** (Zeits. Instrumentenk. 42. pp. 221–231, Aug., 1922. From the Phys. Techn. Reichsanstalt.)—The latest determinations of the e.m.f. of the international Weston element were made in the year 1910 in Washington and at the National Physical Technical Institution in Charlottenburg. In Washington there took place in the year mentioned an international co-operative work of the various State laboratories, to which dealing with electrical units appertained, by which the units of resistance and of e.m.f. of England, the United States, and Germany were compared together, and the e.m.f. of the Weston normal element through investigations undertaken in common was determined afresh. Simultaneously in the Reichsanstalt a new determination of the e.m.f. of the Weston cell was undertaken. The results were published partly in the Report of the International Committee on Electrical Units and Standards, Washington, 1912; partly in a publication of the Reichsanstalt [Steinwehr, see Abs. 333 (1914)], and were so surprisingly good that through these researches both the international agreement upon electrical units and the value of the Weston element appeared to be made certain and established for the future. Notwithstanding, after an interval of about ten years caused by the war, the unit of e.m.f. by means of the silver voltameter underwent a new test. Moreover, this direct control received a wider scope through the appearance of a large series of new elements. The fundamental idea in this new research was that each newly described element must show the correct e.m.f. and consequently should serve for the fixing of the apparently temporary changes of the older elements.

(1) A description is given of the *silver voltameter measurements* which were made in the laboratory for fundamental units and consequently no direct measurement was carried out, but only an indirect comparison

by means of a number of elements which in the laboratory for fundamental units are built into the wall. The electrical determinations were undertaken in common by both authors, whilst the work of determining the silver deposit was undertaken by the last-named only. The weighings were carried out by means of the Rueprecht balance. The principle of the methods employed in the research are the same as those already described [Jaeger and v. Steinwehr, Abs. 287 (1909)]. The measurement of the current by means of the compensation apparatus was made every minute—with stronger currents more frequently. Between these measurements the strength of current was controlled by comparison with a Weston normal element (Cd_8), which was kept in a petroleum bath whose temperature was read at equal intervals during the whole duration of an experiment. This element was itself at the end of each investigation compared with a set of ten Weston elements, kept in a box with walls of a thickness of 60 cm. to guard against sudden temperature changes.

According to the formula used in the earlier research for the calculation of the e.m.f. by means of the silver voltameter, there is given for the mean E_m of the 10 normal elements joined directly to the silver voltameter the following equation, which gives the value of the mean E_m

$$E = 894 \cdot 45 \,.\, \frac{GRW_m(WCd_8)}{1WCd_8(W_r)} \,.$$

In this formula G signifies the weight of the silver deposit in grammes, R the value of the normal resistance in ohms, by help of which the measurement of the voltameter current was carried out, W_m the expression for the mean of the 10 comparison elements in the compensator, (WCd_8) and W_r) the temporary mean values, during the duration of the experiment of the reading on the compensator for the element Cd_8, which during the experiment was measured from time to time, and for the potential difference at the ends of the normal resistance R traversed by the voltameter current. Upon the accuracy with which the units in the formula can be measured the previously published communication deals.

Elaborate tables giving the results of the investigations, are given, but the general result shows that there is a quite remarkable agreement with the values obtained in the year 1910, so that there is no occasion for change in the final mean value found, viz. 1·01831.

(2) As a second control for the constancy of the e.m.f. of the element the production of *new elements* was made use of. From the mercury sulphate preparations in the Reichsanstalt were prepared in the years 1920 to 1922, 69 elements under check of all the foreseen rules of mass. The result showed that the mean e.m.f. of the element is unchanged, and therefore again on this ground also the value 1·01831 may be taken as the true mean value. The results of these observations are given in tables.

In a series of experiments the variations of the Clark cell from the mean were found to be greater than in the case of the Weston cell.

J. J. S.

373. *Calibration of Cells for Conductivity Measurements.* **C. A. Kraus and H. C. Parker.** (Am. Chem. Soc., J. 44. pp. 2422–2428, Nov., 1922.)—The data necessary for making up standard potassium chloride solutions, according to the weight method, for calibrating conductivity cells are given correctly by Kohlrausch and Holborn for 1·0N solutions only, their directions for preparing 0·1, 0·02, and 0·01N solutions being erroneous; the error amounts to 0·10 % and 0·54 % for the 0·1N and 0·01N solutions respectively. The conductivity data of Kohlrausch and Holborn ("Leitvermögen der Elektrolyte") are not sufficiently accurate at the present day, and their replacement by those given by Kohlrausch and Maltby is recommended. The data required for making up 1·0N, 0·1N, and, 0·01N potassium chloride solutions by the weight method are detailed. Taking the value, namely 0·011203, determined by Kohlrausch and Maltby for the specific conductivity of 0·1N potassium chloride solution at 18°, the value at 25° is found to be 0·0128988. This value may be used for the purpose of calibrating cells at 25°, the necessity for making determinations at 18° being thus avoided. T. H. P.

ALTERNATING CURRENTS AND MAGNETISM.

374. *Calculation of Natural Frequency of a Long Two-Layer Coil.* **W. Schröder.** (Archiv f. Elektrot. 11. pp. 203–229, Sept. 10, 1922.)—The author points out that the problem of determining the natural frequency of a coil has become a pressing one to engineers concerned with heavy alternating-current work since it has been recognised that dangerously high voltages may be caused by a coil whose natural frequency coincides with that of a transient wave set up in an alternate-current system of which it forms a part during variations of the latter, such as may occur, *e.g.*, during starting up or throwing a generator in or out. References are given to a number of previous investigations, notably one of Lenz, who obtained solutions, under certain limitations, of the problem for single-layer coils [see Abs. 1107 (1914)]. The present paper, in which Lenz's methods have been extended to the case of a two-layer coil, is the outcome. To avoid apparently insuperable mathematical difficulties, the coil is represented by a pair of coaxial, circular cylinders of infinite length, a system for which the electric field is determinable. The problem has been further simplified by the assumption that the distance separating the two layers is small compared to the radius of the coil. The solution for such a system is given by the equation $\lambda = 2\mathrm{L}\sqrt{i\pi \mathrm{R}/d \,.\, \mathrm{J}_1(i\alpha)\mathrm{H}_1{}^{\mathrm{I}}(i\alpha)}$, where λ is the ether wave-length, L the length of either winding, their difference being assumed negligible, R the radius of either winding, $2d$ the distance between the windings. In the numerical calculation the values of the Bessel and Hankel functions have been taken from the tables of Jahnke and Emde. Before applying this formula to an actual coil in which the length is large relatively to the radius, and the radius is large relatively to the distance between the two layers, to which alone it is applicable, a correction must be applied taking account of the wire being of circular section and covered with a finite thickness of an insulating material, instead of being of rectangular section without a finite thickness of insulation. This correction is obtained from the condition that the capacity of the coil in question must be equal to that of the ideal model, and its effect is confined to substituting for d a different value d'. To calculate the capacity of a coil the potentials must be determined, but only infinitely near to the coil turns. The latter condition makes the problem a two-dimensional one, the coil being assumed to be replaced by two parallel wire gratings of infinite length. Their accurate determination, even then, involves an immense amount of laborious calculation leading to the expression of the potentials in terms of Lenz's Gitter-functionen (grating functions). The author gives illustrations of various methods of approximation by means of which results accurate to within from 4 % to 1 % can be obtained. He also points out that much of the work might be carried out once for all and tabulated, and he urges that the technical importance of being able to make such determinations with accuracy and yet with a comparatively modest expenditure of labour would fully justify this being done. G. W. DE T.

375. *The Physical Aspect of the Propagation of Alternating Currents on Long Lines.* **P. Boucherot.** (Rev. Gén. d'Él. 12. pp. 499–505, Oct. 7, 1922.)—The author first shows that the propagation of electrical energy on long lines can be considered from three different physical aspects of equal mathematical value. Of these, one seems to be more in accord with modern ideas of physics than the others, namely that which supposes the existence of two simple waves propagated along the lines in opposite directions with equal speeds. It is then shown, by calculation of the real and the reactive power, how the current and voltage due to these two waves can be simply related. For both of the waves the current and voltage are in a constant ratio and have a constant phase-displacement between them, the ratio and phase-angle being dependent only on the characteristics of the line. The mathematical theory is simply developed without the use of imaginary quantities, and the paper concludes with numerical application of the results to a three-phase line of high power. B. H.

376. *Axial Effects in Magnetic Field.* **A. Sellerio.** (Comptes Rendus, 175. pp. 757–758, Oct. 30, 1922.)—Analogous to Righi and Leduc's transverse thermo-thermic effect and Ettingshausen's transverse galvano-thermic effect, the author has found an axial thermo-thermic effect and an axial galvano-thermic effect. [See also Abs. 387 and 388 (1922).] A. D.

377. *Calculation of the Attraction of Electromagnets.* **A. Guilbert.** (Comptes Rendus, 175. pp. 615–617, Oct. 16, 1922. Rev. Gén. d'Él. 12. pp. 714–718, Nov. 11, 1922.)—The paper is mainly mathematical, special attention being given to the effects of hysteresis. A. B. C. L.

378. *A Preliminary Magnetic Study of Some Heat-Treated Carbon Steels.* **E. D. Campbell** and **E. R. Johnson.** (Iron and Steel Inst., J. 106. pp. 201–222, 1922.)—In this investigation of the facts of permanent magnetism four steels were tested very thoroughly, with a gravity balance magnetometer, through a long range of heat treatment, the bars being first quenched in cold water from 851° C. to 910° C., permanently magnetised to saturation by a very systematic method, and placed in position in a vertical coil of the magnetometer, with the lower end at a definite distance from a disc of carefully annealed electrolytic iron, which was attached to one end of the balance beam of "Armco" iron. The attraction between the permanent magnet bar and the disc was measured in dynes, with zero current in the coil and with currents in the direction required to increase the field, varying in eight steps from 0·10 to 0·80 ampere. The current required to demagnetise the bar, and that required to double the attraction of the disc were determined, and all these measurements were repeated, after successive annealings at about 100° C., 200° C., and so on by steps of about 100° C., up to about 800° C. The conclusion drawn from these measurements is that the carbides have a magnetomotive force, which is dependent on the chemical constitution, but is independent of the size of the particles; that since the permanent magnetic field is dependent on both the magnetomotive potential and the magnetic resistance, and since the former increases only slightly above the eutectoid point, while the latter increases rapidly, the strongest permanent field can usually be developed by proper heat-treatment of slightly hypo-eutectoid steel. A hypothesis is suggested to account for permanent magnetism in steel, based on the Lewis-Langmuir concept of the iron and carbon atoms; the electrons by their rotations producing magnetic fields, and their axes setting themselves in definite positions in the atoms in the magnetised and non-magnetised conditions. H. N. A.

379. *Does the Critical Point Depend on the Strength of the Magnetising Field?* **K. Honda.** (Iron and Steel Inst., J. 104. pp. 185–190, 1921.) —The critical point, or the A2 transformation point, of iron or steel is defined as the temperature at which ferro-magnetism vanishes. Experiments to determine this point with the magnetometer show that it is practically independent of the field intensity; and, in order to investigate the matter with greater accuracy, the author has made use of a special torsion balance method, the details of the instrument employed being given in a paper by T. Ishiwara [Abs. 1333 (1920)]. The observations were made *in vacuo*, to avoid oxidation of the specimens, which were renewed after each heating to avoid complications due to decarburisation in the case of steel. Using fields ranging from 400 to 2150, it was found that, for pure iron and for two steels with 0·68 and 1·17 per cent. of carbon, the critical point remained unchanged with change of field. The experiments indicate that the magnetic, or A2, transformation is probably a progressive change, which takes place within the molecules as the temperature rises, the change of magnetisation being one aspect of this internal transformation. H. N. A.

380. *Magnetic Declination.* **R. Abels.** (Terrest. Magn. 27. pp. 119–120, Sept., 1922.)—The magnetic needle reached recently its maximum eastern declination in Siberia, and has begun its reverse movement towards the west. The first observations at Ekaterinburg were made in 1761 and since then, until 1916, the north end has moved east at an annual rate of about 4 mins. In 1916–17 it remained stationary and then in 1918 moved 0·3 min. west. The reverse movement began earlier in Siberia than at Ekaterinburg. There can be no doubt that the western movement will begin soon in Europe. W. A. R.

381. *Magnetic Measurements Around Paris.* **L. Eblé.** (Comptes Rendus, 175. pp. 494–496, Sept. 25, 1922.)—Forty-one sets of measurements are given. The secular variations from January 1, 1896, to January 1, 1922, are: Declination, − 2°58′; inclination, − 0°32′; and horizontal component + 0·0014. W. R. C.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

382. *Absorption of Water by Soil Colloids.* **W. O. Robinson.** (J. Phys. Chem. 26. pp. 647–653, Oct., 1922.)—Constant absorption of water was found to prevail over the 34 samples of soils from which the colloidal matter was extracted. It is suggested that the colloidal matter in a soil might be estimated fairly closely by determining the water absorption of the soil and dividing the result by the average factor 0·298.

F. J. B.

383. *Diffusion and Intertraction.* **C. G. Schoneboom.** (Roy. Soc., Proc. 101. pp. 531–539, Sept. 1, 1922.)—When blood serum is run carefully on to the surface of a 5 or 8 per cent. sodium chloride solution in a test-tube or flat glass cell, a mass movement starts immediately, the upper fluid being carried down into the lower, and the lower into the upper. This phenomenon, which is termed intertraction or pseudopodial interpenetration, is rendered clearer if the serum is coloured with a trace of a dyestuff. It is now found that similar phenomena are obtained, not only with colloidal solutions, but with all inorganic and organic compounds without exception, provided that the substances in question are sufficiently soluble in water, that there is not too great a difference in specific gravity between the upper and lower solutions, and that these do not react chemically. Size of molecule and presence or absence of water of hydration are without influence on the phenomenon, which is determined solely by surface tension forces. When the difference in specific gravity of the two superposed layers is greater and also when the relations of the surface tensions are different from those under which the pseudopodial intertraction occurs, another form of mixing, termed "simple intertraction," takes place, there being a gradual transition between pseudopodial intertraction, simple intertraction, and the well-known slow processes of diffusion. T. H. P.

384. *The Solubility of Helium in Water.* **H. P. Cady, H. M. Elsey, and E. V. Berger.** (Am. Chem. Soc., J. 44. pp. 1456–1461, July, 1922.)—The solubility of helium was determined between + 2° and + 30° C. Taking the solubility as given by $273 \cdot 1 \times V_1/TV$, where V and V_1 are the volume of water and the volume of helium absorbed in this volume and T is the absolute temperature, the solubility at 25° C. is about 0·00860. The value is smaller than that obtained by other observers, with one exception of a single value by Ramsay. The coefficient of solubility decreases with rising temperature, and there is no sign of a minimum.

W. R. C.

385. *Heat of Crystallisation of Quartz.* **R. C. Ray.** (Roy. Soc., Proc. 101. pp. 509–516, Sept. 1, 1922.)—Preparatory to the determination of the heat of solution of crystalline and vitreous silica in aqueous hydrofluoric acid, experiments are described in which the specific heats of the latter at various concentrations are ascertained. The heat of crystallisation of quartz at the ordinary temperature, as represented by the difference between the heat of solution of quartz and silica glass in aqueous hydrofluoric acid, is found to be equal to 6·95 kg.-cals., and it is shown that grinding affects the crystalline material, which is partly converted to the vitreous state. A calculation of the latent heat of crystallisation of quartz at higher temperatures shows that near the melting-point the heat of crystallisation of quartz is very nearly equal to that at the air temperature. A. B. C. L.

386. *Separation of Isotopes by Distillation and Analogous Processes.* **R. S. Mulliken.** (Am. Chem. Soc., J. 44. pp. 2387–2390, Nov., 1922.)—The results of further experiments [Abs. 1403, 1919 (1922)], in which the progress of the separation of the isotopes of mercury by distillation was followed by determinations of the density, give for the separation coefficient of mercury the value 0·0063, instead of 0·0057, as previously found [cf. Brönsted and Hevesy, Abs. 1735 (1922)]. The effect of various factors on the efficiency of separation of isotopes by the method of non-equilibrium distillation has been studied. An efficiency of 50 % is very easily obtained, and a film of dirt increases the efficiency at the higher rates. The possibility of applying irreversible distillation as a new factor in the separation of non-isotopic liquid mixtures is indicated. Attempts to effect a separation of the isotopes of mercury by electrolytic solution or by reaction with sulphur were unsuccessful, the failure being ascribed to the great difficulty of obtaining non-equilibrium conditions at the boundary between two condensed phases. T. H. P.

387. *Limits for Flame Propagation in Vapour-Air Mixtures.* II. *Mixtures of Air and more than One Vapour at Ordinary Temperature and Pressure.* **A. G. White.** (Chem. Soc., J. 121. pp. 2561–2577, Nov., 1922.)—The experiments are conducted as in Abs. 2346 (1922)], but dried air was used only for mixtures containing either alcohol or acetone. For the two-vapour mixtures—carbon disulphide always excepted—the results, as regards the lower limit in all directions of propagation, and for downward propagation at the upper limit, agreed well with le Chatelier's formula. The anomalous behaviour of acetone vapour was, however, also noticed in the more complex mixtures. The rule did not hold either for any direction in which one of the two vapours could propagate a cool flame. When the second vapour gave no cool flame, the propagation of the cool flame of the first vapour was hindered by the presence of the second vapour; by adding a non-cool flame vapour to ether-air, the mixture-air propagation range could be divided into a cool range and a normal range, even with upward propagation. Carbon disulphide mixtures deviated considerably from the Chatelier formula, and previously noticed cases of agreement were found to be accidental. Ordinary propagation in CS_2 seems to be catalysed, presumably by some product of the combustion; but this catalytic process is inhibited by some of the vapours used in these experiments (such as benzene, ether-acetone, acetaldehyde), not apparently by small amounts of CO_2 and CCl_4, nor by some combustible gases. These peculiarities are further investigated. H. B.

388. *Photochemical Investigation of the Action of Ferric Salts on Iodides.* **N. Sasaki.** (Kyoto Coll. Sci., Mem. 5. pp. 315–327, June, 1922. In German.)—The reaction between ferric salts and iodides, and also that between ferrous salts and iodine, exhibit distinct sensitiveness towards the light of the sun or of an incandescent electric lamp, the former reaction being retarded and the latter accelerated. Contrary to what is observed with the ordinary union of iodine, and with rise of temperature, the dark equilibrium is displaced towards the formation of iodide by the action of light, a well-defined equilibrium, dependent on the intensity of the light, being attained. T. H. P.

389. *The Chemical Constants of some Diatomic Gases.* **J. R. Partington.** (Phil. Mag. 44. pp. 988–993, Nov., 1922.)—The constant C in Langen's equations [Abs. 1499 (1920)] has been calculated by him for several gases from the experimental data. Nernst has also calculated C by a somewhat arbitrary method; but although his results provide a satisfactory approximation for particular problems, they are not in accordance with modern theories of specific heats [Partington, Thermodynamics, p. 496, 1913]. The method of calculation adopted by the author is that of generalised statistical mechanics, and the truth of the quantum theory is assumed. The following values are obtained for C: Oxygen 1·001. The four values obtained by Langen range from 0·539 to 1·021, the mean being 0·829; nitrogen 0·904, Langen giving only one value − 0·05. The case of hydrogen is probably not satisfactorily covered by the formula obtained in this paper, since the value of C_p becomes appreciably reduced within a region of temperature before the value of *c* for the condensate becomes negligibly small. This gas should behave in a manner intermediate between that of a monatomic and a diatomic gas. Nernst from the monatomic formula finds C = − 1·23, Langen obtains C = − 3·767, and the diatomic formula gives − 2·255. For molecules composed of two different atoms the following values have been calculated, the first figure being that of the author, the second that of Langen, and the third that of Nernst:

Carbon monoxide	1·205, − 0·04, 3·5.
Nitric oxide	1·263, 0·92, 3·5.

The gas molecule is supposed to consist of two atoms rigidly attached to one another at a fixed distance. Rotation about the molecular axis is ignored. If the atoms are identical, K is the radius of gyration of the molecule and M is the mass of a gramme molecule $C = 2·5 \log M + 2 \log K + 12·73$. In the case considered $K^2 = r^2$, where r is the radius of the molecule. H. N. A.

390. *Properties and Molecular Structure of Thin Films. III. Expanded Films.* **N. K. Adam.** (Roy. Soc., Proc. 101. pp. 516–531, Sept. 1, 1922.) Experiments described in a previous paper [see Abs. 6 (1923)] are continued with an extension of the range of temperature employed. Previous results showed that, within the accuracy of experiments, the mechanical properties of condensed films are independent of temperature. Above a certain temperature, depending on the nature of the substance in the film and on the composition of the solution, all films expand along the surface. The compression curves of expanded films of myristic acid on HCl solution are given for various temperatures, and their characteristics discussed. No appreciable hysteresis is observed with expanded films. Tables are given showing the expansion of films of fatty acids on dilute HCl at 1·4 dynes/cm. compression, and of various esters, amides, etc., on distilled water at

the same compression. The analogy between expanded films and gases is supported and discussed. The results of experiments recorded in this and in preceding papers are reviewed in relation to the orientation of the separated molecules in expanded films, the crystal structure of fatty acids and their esters, and the independence of the properties of solubility in the underlying solution and expansion along the surface.
A. B. C. L.

391. *Degree of Molecular Polymerisation of Substances in the Critical State.* **J. A. Muller.** (Comptes Rendus, 175. pp. 760–761, Oct. 30, 1922.)—The degree of polymerisation in the critical condition has been calculated for a number of elements and inorganic and organic compounds. With the exception of helium, all the substances examined contain polymerised molecules, those which are almost perfect gases at the ordinary temperature and at about atmospheric pressure showing, under critical conditions, comparatively slight polymerisation. For liquid hydrocarbons and monohalogenated derivatives of benzene the degree of polymerisation lies between 1·39 and 1·45, and for esters of saturated monobasic fatty acids between 1·45 and 1·48. Higher values are shown by the alcohols, while nitrites, water, and acetic acid have mean degrees of polymerisation of about 2.

The influence of isomerism on the degree of polymerisation at the critical state is slight, when the isomeric compounds are similar chemically.
T. H. P.

392. *The Law of Distribution of Particles in Colloidal Suspensions, with Special Reference to Perrin's Investigations.* **A. W. Porter** and **J. J. Hedges.** (Faraday Soc., Trans. 18. pp. 91–99; Disc., 99–101, Oct., 1922.)—The distribution of particles in a colloidal solution is found to follow the relation deduced by Perrin only in a narrow layer immediately below the surface. Beyond this region the concentration approaches a limiting value which remains approximately constant throughout the bulk of the solution. Measurements of concentration at varying depths below the surface are found to agree closely with a relation of the form: $\frac{dn}{dy} = \mathrm{K}n(1 - bn)^2$, or by integration, $\log_e \frac{n}{1 - bn} + \frac{1}{1 - bn} = \mathrm{K}y + \mathrm{A}$, where m is the mass of a particle, n their number, y the depth of solution, γ the density of the particles, and $\mathrm{K} = \frac{g\mathrm{N}m(\mu - \gamma)}{\mathrm{RT}u^2}$, where $1/\mu$ is the specific volume of the solvent and N is Avogadro's number. As in van der Waals' formula, b represents the effective volume of the particles, or more strictly, "the internal virial arising from molecular repulsions during collisions." In measurements with gamboge suspensions the numerical value found corresponds to the effective volume of the particles, being of the order of the volume of the solution itself. The large value thus obtained would indicate that, even when particles are at a distance from one another, much greater than that which denotes their size when it is estimated by optical examination with a microscope, the particles begin to experience a mutual repulsion, or, in other words, the actual visible particle is connected in a semi-rigid way with a very large quantity of the surrounding fluid. Loose combinations are thus formed between the particles and large masses of water, each such aggregate moving as a single molecule, as far as kinetic theory is concerned. This property is analogous to the case of sugar, the molecule of which in solution is attached more or less rigidly with at most a single layer of water molecules. The value of *b* with gamboge suspensions is found to be higher with dilute than with more concentrated suspensions. The effective size of the nucleus, for example, diminishes to one-half when the suspension is reduced to half strength. This observation is in accordance with the behaviour of sugar for which substance more molecules of water were found to be attached to each molecule of sugar in the case of a dilute solution than with a strong one. The explanation of Burton that the nature of distribution observed is due to electrical repulsion through charges on the particles is considered to be untenable since if the particles contained charges of one sign they would tend by repulsion to concentrate at the boundaries. Further, as the solution as a whole is unchanged, it follows that an opposite charge or double layer must accompany any charge on the particle. The possibility is indicated that there may still remain some force between the particles which operates in the distribution.

[Reference to other aspects of this paper in another publication is made in Abs. 219 (1923)]. J. N. P.

393. *Preparation of Colloidal Solutions of Nickel and Cobalt Hydroxides and some other Compounds of these Metals.* **O. F. Tower** and **M. C. Cooke.** (J. Phys. Chem. 26. pp. 728–735, Nov., 1922.)—Colloidal solutions of nickel hydroxide may be prepared by (1) dialysing nickel tartrate solution in presence of an alkaline potassium tartrate solution, or (2) a special method of precipitating and washing the hydroxide itself. Only very dilute colloidal solutions of cobaltous hydroxide are obtainable by these methods. Glycerol does not prevent the precipitation of nickel hydroxide from aqueous solutions. In alcohol solutions, interesting transformations occur, a solution being eventually obtained from which nickel hydroxide cannot be precipitated by dilution with water. Colloidal solutions of nickel sulphide, which are readily formed in presence of an alkaline solution of a tartrate, decompose immediately, with precipitation of the sulphide, when the tartrate is dialysed out. T. H. P.

394. *Coagulation of Manganese Dioxide Sol by Different Electrolytes.* **P. B. Ganguly** and **N. R. Dhar.** (J. Phys. Chem. 26. pp. 701–714, Nov., 1922.)—The values obtained by the authors for the coagulative powers of different electrolytes on manganese dioxide sol are only partially in agreement with the Schulze-Hardy law, according to which the precipitating action of an ion increases with its valency. Change of concentration markedly changes the order of the coagulative powers of electrolytes on this sol. Thus, it appears that valency is by no means the chief criterion in determining the activity of ions in coagulating colloidal solutions, the coagulative power being rather a specific property of ions. The influences of the anions, the time allowed for coagulation and the concentration of the colloidal solution on the coagulative powers of ions, are found to be very marked. T. H. P.

395. *The Molecular Theory of Solution. II.* **S. C. Bradford.** (Phil. Mag. 44. pp. 897–904, Nov., 1922.)—The author further [see Abs. 274 1920)] shows how the cohesion of the solvent, the adhesion of solvent and solute, and the cohesion of the solute influence solubility. On the assumption of molecular fields of force, moreover, not only solubility, degree of hydration, heat of solution, molecular volume and compressibility, but also depression of freezing-point, elevation of boiling-point, electric conductivity, and osmotic pressure should follow the order of the surface tensions. Taking the accepted freezing-point data of some alkali and other salts in aqueous solutions and the corresponding surface tensions (determined from the capillary rise), he concludes that the observed increases in the depression of the freezing-point of aqueous solutions of salts above that due to a normal solute are caused by the enhanced intrinsic pressures resulting from the greater molecular fields of the solutes. That would imply a verification of Walden's relation. H. B.

396. *X-Ray Examination of Strained Metal.* **A. Ono.** (Kyushu Univ. Coll. Eng., Mem. 2. 5. pp. 241–260, 1922. In English.)—Strained metal —chiefly copper wire—was examined by taking Laue photographs of the material both as annealed and after being subjected to varying amounts of drawing. The interference figures obtained from the strained metal showed a series of bands radiating from the central spot; these bands become more marked as drawing proceeds. Measurement of the angles between these bands show that they can be explained on the assumption that the diagonal of the cubic lattice of crystallisation of the metal coincides with the direction of drawing (the fibre direction of the specimen). Calculation as to the intensity of the bands confirms this assumption, at least qualitatively. Existing hypothesis explaining the mechanism of strain are briefly discussed. J. L. H.

397. *Manufacture and Treatment of High-Speed Steel.* **H. K. Ogilvie.** (Iron and Steel Inst., J. 106. pp. 155–165; Disc. and Corres., 166–173, 1922.)—This paper deals with the manufacture of high-speed steel tools, from the making of the steel to the finished article. The author discusses the use of the crucible and electric furnace, the casting of ingots, and the manufacture, hardening, and testing of tools.

In the *discussion*, **C. G. Carlisle** criticised the author's explanation of gas trouble and his treatment of billets after forging; **H. Brearley** criticised the economic basis of the paper and suggested the use of mixed greasy and oxidised turnings in the electric furnace. **V. Stobie** also referred to the use of turnings and criticised the figures given by the author for loss in the electric furnace. In the correspondence, **J. F. Kayser** favoured the use of tungsten powder as against ferro-tungsten, and criticised the author's terminology in connection with hardness. J. L. H.

398. *Volume Changes of Steels during Heat Treatment.* **L. Aitchison and G. R. Woodvine.** (Iron and Steel Inst., J. 106. pp. 175–190; Disc. and Corres., 191–192, 1922.)—The author describes a series of experiments on air hardening nickel-chromium steels. Specimens heated to 830° C. in a muffle furnace and air cooled are taken as "standard." Specimens so treated, and then heated in a dilatometer to 850° C. and allowed to cool to atmospheric temperatures *in situ*, are taken as "semi-standard." The experiments, carried out on the "semi-standard" steels, are a series of temperings at various temperatures, showing the effects on the volumes of the specimens. In the *discussion*, **E. H. Saniter** criticised the use of the term "volume change" for the longitudinal expansion and contraction recorded by a dilatometer. In the correspondence, **J. H. Andrew** made a similar criticism, and expressed his surprise at the selection of such a meta-stable state for a "standard" condition. J. L. H.

399. *Characteristic Curves of Heat Treatment of Steels.* **A. M. Portevin** and **P. Chevenard.** (Iron and Steel Inst., J. 104. pp. 117–135; Disc. and Corres., 136–140, 1921.)—A graphic representation of the results of any heat treatment is put forward. The fundamental factors, temperature of heating and rate of cooling, are taken as coordinates and varied so as to produce constant properties. Only simple heat treatments are considered. In the case of air coolings the rate of cooling is evaluated by the initial rate, and in the case of immersion in a liquid the average rate of cooling over a range of temperature is used. The property whose modification is studied is in every case the Brinell hardness, indications of the other mechanical properties being obtainable from this. The other physical properties may be arrived at by a consideration of the nature of the constituents of the steel. A quantitative evaluation of the intensity of the transformations which give rise to a given state is obtained by the differential dilatometric method. Variations in the intensity of the various transformations indicate the quantities of constituents produced. By varying simultaneously the initial temperature of heating and the rate of cooling, it is possible to plot the geometrical area of the various characteristic limits of the different states in terms of the coordinates. Characteristic curves of heat treatment for the given steel are thus obtained. Characteristic curves of the most important and the most interesting steels from the variety of states practically obtainable are plotted, notably of manganese and nickel-chromium steels. It is assumed that the original state of the steel before heat treatment is standardised. J. L. H.

400. *Flow of Steels at a Low Red Heat and Scaling of Heated Steels.* **J. H. S. Dickenson.** (Iron and Steel Inst., J. 106. pp. 103–140; Disc. and Corres., 141–154, 1922.)—The first portion of the paper contains an account of experiments on a series of steels containing 2 plain carbon steels, 1 nickel-chromium, 1 high chromium, and 1 high-speed steel, and a nickel chromium alloy, to determine their resistance to deformation by stress at elevated temperatures. Three types of experiment are carried out: (*a*) Rapidly applied load at temperatures between 15° C. and 1000° C., (*b*) prolonged tests at constant load and temperature, and (*c*) tests at constant load and uniform rate of heating. It is clearly shown that time has an enormous influence on the resistance of a given alloy to tensile stress. In selecting material for resistance to stress at elevated temperatures, the nature of the stress must be considered. The latter portion of the paper describes the effect of heating eight typical steels and one nickel-chromium alloy at various temperatures from 550° C. to 1125° C. with reference to the amount of scaling. An electric muffle furnace is used up to 900° C., and a gas-fired muffle furnace above this. Apparently the results may be approximately stated by the law $R \propto T^n$ where R is the rate of scaling and T is the absolute temperature. Photographs showing the nature of the scaling are given. The nickel-chromium alloy is particularly resistant to oxidation.

In the correspondence **P. Chevenard** gave an account of similar experiments carried out at the Imphy Steel Works, France. **C. H. Desch** showed, by examination of the curves given in the paper, that the flow of the metals under stress was of a more complicated character than pure viscous flow. J. L. H.

401. *Oxychlorides of Mercury. Equilibrium in the System: Mercuric Chloride, Yellow Mercuric Oxide, Water, at 35° C.* **S. Toda.** (Kyoto Coll. Sci., Mem. 4. pp. 305–310, March, 1921. In English)—The solubility of mercuric chloride at 35° C. is found to be 8·53 grms. per 100 grms. of solution or 9·39 grms. in 100 grms. of water, and that of yellow mercuric oxide 0·0014 grms. per 100 grms. of either solution or water. Only two oxychlorides are found to exist, namely, $HgCl_2$, 2HgO, and $HgCl_2$, 4HgO; the latter probably forms solid solutions with yellow mercuric oxide. T. H. P.

402. *Study of the Reciprocal Salt Pairs: $2NaCl + MgSO_4 \rightleftharpoons Na_2SO_4 + MgCl_2$, at 25° C.* **S. Takegami.** (Kyoto Coll. Sci., Mem. 4. pp. 317–342, March, 1921. In English)—The solubilities of these four salts have been determined and investigation made of the equilibria between two salts with a common ion and between three of the salts. Nine solid phases exist in the equilibrated system of the reciprocal salt pairs, namely: Na_2SO_4, $10H_2O$; Na_2SO_4; NaCl; astracanite, Na_2SO_4, $10H_2O$; $MgSO_4$, $7H_2O$; $MgSO_4$, $6H_2O$; $MgSO_4$, $5H_2O$; $MgSO_4$, $4H_2O$ and $MgCl_2$, $6H_2O$. The results obtained are given in tabular and graphic form. T. H. P.

403. *Equilibrium in the System: Copper Sulphate, Ammonium Sulphate, Potassium Sulphate, and Water, at 25° C.* **R. Hayami.** (Kyoto Coll. Sci., Mem. 4. pp. 359–369, March, 1921. In English.)—This equilibrium has been investigated and the relation between the composition of aqueous solutions and that of the solid solutions determined when the residue is a mixture of $CuSO_4$, $5H_2O$ and $CuSO_4$, $(NH_4, K)_2SO_4$, $6H_2O$, and also when it is a mixture of $(NH_4, K)_2SO_4$ and $CuSO_4$, $(NH_4, K)_2SO_4$, $6H_2O$. T. H. P.

404. *Equilibrium in the System: Potassium Chlorate, Potassium Nitrate, and Water, at 25° C.* **S. Toda.** (Kyoto Coll. Sci., Mem. 4. pp. 377–382, May, 1921. In English)—The solubility of potassium chlorate at 25° C. is found to be 7·745 grms. per 100 grms. of solution or 8·395 grms. in 100 grms. of water, and that of potassium nitrate 27·24 grms. per 100 grms. of solution or 37·44 grms in 100 grms. of water. At 25° C. potassium chlorate takes up potassium nitrate to form a solid solution to the extent 14·37 mol. %, whilst the chlorate is not taken up by the nitrate. T. H. P.

405. *The Application of Thermodynamics to Heterogeneous Equilibria.* **G. W. Morey.** (Frank. Inst., J. 194. pp. 425–484, Oct., 1922.)—The present compilation represents the subject matter of four lectures whose underlying purpose has been to present, in as simple a form as possible, the fundamental features of that portion of Gibbs' great paper, "Equilibrium of Heterogeneous Substances," which lead up to, and are essential to, the development of his equation 97, $Vap = Sat + m_1 d\mu_1 + m_2 d\mu_2 + \ldots + m_n d\mu_n$. This equation is emphasised throughout as a powerful weapon for attacking the problem of equilibrium between phases, and affords a more direct and simple, as well as a far more potent, attack than does the usual statement of the phase rule, which is but an incidental qualitative deduction from it. By the detailed application of this equation, problems of heterogeneous equilibria may be solved completely if the entropy and volume changes are known in their entirety. But more than this, by the application of this equation, and such a general knowledge of entropy and volume differences as are involved in the knowledge that a vapour phase has a greater entropy and volume than the liquid phase with which it is in equilibrium, or that the high-temperature modification of a phase has a greater entropy than the low-temperature modification, it is possible to predict, with an approach to quantitative accuracy, the behaviour of the system when subjected to changes in pressure, temperature, and composition. Furthermore, this thermodynamic method is not limited in its application to two or three component systems, but can be extended readily to include any desired number of components. A sharp line has to be drawn, however, between those relations which are derived from the two laws of thermodynamics without the aid of further assumptions, and those whose derivation involves not only the thermodynamic laws proper, but also further assumptions extraneous to thermodynamics. To this latter class belong the dilute solution approximations. In dealing with dilute solutions, it is usual to assume some relation between composition and thermodynamic properties which will enable a divariant equilibrium such as that between ice and a dilute salt solution to be treated as a univariant equilibrium. It was shown by Gibbs that when the amount of one component approaches zero, such a relation becomes possible, and he indicated the form the relation would take. Making certain explicit assumptions, he further identified the constant value which the rate of change of the potential of water with addition of salt approaches as the amount of salt approaches zero, with the gas constant for one gramme of the solute. On these assumptions, the derivation of the ordinary dilute solution laws is easy, and this method of derivation has the advantage of confronting us squarely with the assumptions involved in these dilute solution approximations. The lectures include a discussion of most of the main thermodynamic propositions.

H. H. Ho.

406. *Potential Difference between Two Liquid Phases.* **E. Baur.** (Zeits. Elektrochem. 28. pp. 421–422, Oct. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—If the aqueous solution of a salt is shaken with a solvent which mixes either not at all or only partially with water, when equilibrium is established a difference in potential is, as a rule, to be expected at the surface of contact of the phases. In a cell of the form,

$$\underset{\pi_1}{M \mid} \text{ MS (Phase I) } \underset{\pi_3}{\mid} \text{ MS (Phase II) } \underset{\pi_2}{\mid} M,$$

where M is a metal and MS one of its salts, besides the required p.d. π_3, two others, π_1 and π_2, are set up; since the sum of these three is zero, π_3 will be zero when $\pi_1 = \pi_2$.

The author's experiments, made with the help of Lippmann's capillary electrometer, were carried out with mercurous and potassium nitrates, nitric acid, and potassium chloride, which the results of Gouy and of Freundlich indicate to be capillary-inactive. Aqueous solutions of these electrolytes, brought into equilibrium with phenol, furfuraldehyde, propyl, isobutyl, and amyl alcohols, ethyl acetate, ether, chloroform, and aniline, gave in all cases regular Lippmann curves; with the six last solvents, ethyl alcohol had to be added in order to overcome the excessive internal resistance. For corresponding pairs of solutions, $\pi_1 = \pi_2$, so that $\pi_3 = 0$. For the ions concerned, this law may doubtless be extended to all solvents in distribution equilibrium. Probably also it applies to most inorganic, normally mobile ions, but it is possible and even theoretically probable that the large organic, abnormally slow-moving ions develop appreciable distribution potential differences. T. H. P.

407. *Electrical Conductivity of Hydrochloric Acid and Potassium Chloride in Presence of Sucrose.* **A. J. Kieran.** (Faraday Soc., Trans. 18. pp. 119–125, Oct., 1922.)—With a view to ascertaining if sucrose in aqueous solutions is capable of combining and forming a permanent union with hydrogen ion, the equivalent conductivities of hydrochloric acid in widely varying dilutions have been measured at 25° in presence of different proportions of sucrose, the concentration of the latter being kept constant in each series of measurements so that the viscosity also might remain constant while the dilution of the acid varied. It is found that, whilst the behaviour of potassium chloride in presence of sucrose is normal, in that the equivalent conductivity increases regularly with increasing dilution of the salt to an asymptotic limit, hydrochloric acid exhibits abnormal behaviour, since its equivalent conductivity passes through a maximum in the region N/300 – N/500, depending on the concentration of the sucrose solution employed as solvent, and thereafter falls steadily with increasing dilution. This result might be regarded as an indication of the replacement of the fast moving hydrogen ion by a slow moving complex, but detailed examination of the system shows that the abnormal behaviour is not due to this cause, but is connected with the relatively minute traces of electrolytic impurity present even in the purest samples of sucrose obtainable. The nature of this abnormality is of interest, in view of the close association of minimal amounts of electrolytes with other organic substances of high molecular weight.

The best value for m in the equation $\Lambda = \Lambda'\eta^m$, where Λ and Λ' represent respectively the equivalent conductivities in media having the viscosities 1 and η, has been computed for various systems. The results obtained are found to be in accordance with the principle that, the smaller the molecules of the medium and the larger the ions, the more nearly will the value of m approach unity. T. H. P.

408. *An Experimental Note on Complex Ion Formation in Hydrochloric Acid.* **R. M. Hixon.** (K. Vet. Akad. Nobelinst. Stockholm, Meddel. 4. No. 12. pp. 1–8, 1922. In English.)—Arrhenius, as a result of experimental work on neutral salt action, considered the possibility of formation of complex acids of the type H_2CaCl_4. The present investigation was therefore suggested to determine the direction of migration of the metal ion in concentrated HCl, when the solution was subjected to an electric current. This is based on the theoretical deduction that if such a complex was formed, a large concentration of HCl might drive the reaction, $CaCl_2 + 2HCl \rightleftharpoons H_2CaCl_4$, towards the right and possibly give greater concentrations of the negative ($CaCl_4^-$) ion than of the positive (Ca^{++}) ion. The experiments showed migration of the metal towards the anode at medium concentrations, while both dilute and more concentrated solutions showed migration towards the kathode. This migration is considered strong proof of existence of such a complex ion, but the evidence is incomplete until a compound containing it has been isolated. It is pointed out that $HgCl_2HCl$ is known, that the relatively stable Fremy's salt stands in close analogy, while Kendall and Landon's work is briefly outlined. The direction of migration of the metal in the solution will depend upon the relative concentrations of the two ions $[Ca^{++}]$ and $[{}^{-}Cl_x(CaCl_2)_y]$ as well as their migration velocities. At low concentrations of $CaCl_2$ analogy suggests the dissociation to be almost entirely as the simple ions with consequent migration of Ca towards the kathode. With increasing concentration, complex ion formation proceeds more rapidly than dissociation to simple ions giving predominating migration towards the anode. At concentrations approaching saturation of $CaCl_2$, the Ca^{++} may again predominate, due either to the decrease in the [HCl] concentration or to the greater complexity of the acid formed which would be less dissociated than the more simple acid first formed. H. H. Ho.

409. *Bimetallic Electrode Systems in Electrometric Analysis.* I. *Systems Comprising Two Dissimilar Metals.* **H. H. Willard** and **F. Fenwick.** (Am. Chem. Soc., J. 44. pp. 2504–2515, Nov., 1922.)—In electrometric analysis a change which is brought about during titration from a higher to a lower degree of reduction or oxidation is followed by measurement of the charge which, in accordance with the oxidation or reduction potential, is imparted to a piece of platinum foil suspended in the solution. In place of the standard reference electrode, usually the calomel or silver chloride electrode, which is employed in conjunction with the platinum electrode, an electrode of some second metal immersed in the same electrolyte may be employed to indicate the end-point in the titration. Solutions of ferrous sulphate in presence of hydrochloric acid were titrated with potassium bichromate and the p.d. measured between electrodes of platinum and a second metal immersed in the solution. A calomel electrode connecting with the electrolyte could also be brought into circuit by means of a double-throw switch so that the single p.d's could be measured separately. The metals employed for the reference electrodes included Pt, Pd, W, Mo, Ta, and alloys of Au-Pd, and Pt-Rh. The general characteristics observed are that with two metal electrodes the initial voltage, in absence of the product of the higher stage of oxidation, varies considerably according to the pre-treatment of the electrodes and the condition of the solution as to concentration, acidity, and presence of foreign salts. Upon the addition of the oxidising agent, the voltage falls rapidly to practically zero and remains at this point until the titration is near the end-point. A slight rise then gives warning of the approaching end-point which occurs with greater sharpness than with the usual electrode combination. With bimetallic combinations in which tungsten forms one electrode, there is a slow, continuous rise throughout the course of the titration comparable to the rise with monometallic systems, but rarely amounting to 50 millivolts prior to the end-point. Electrodes are found not to behave the same from one titration to another, the break varying in magnitude but not in position. The polarity even may vary at different times, depending largely on the pre-treatment of the electrode. The proposed electrode arrangement, using for instance Pt and Pt-Rh, has the advantage of being essentially simpler than the usual system, with a gain in distinctness of the end-point obtained. J. N. P.

410. *Bimetallic Electrode Systems in Electrometric Analysis.* II. *Theory of Bimetallic Systems: Systems Comprising Two Similar Metals.* **H. H. Willard** and **F. Fenwick.** (Am. Chem. Soc., J. 44. pp. 2516–2529. Nov., 1922.)—Experiments are made to ascertain the cause of the development of an e.m.f. between two adjacent unattackable electrodes which are immersed in the same solution during oxidimetric titrations. Since the electrode potential is determined by the solution pressure of the absorbed gases, it follows that any difference in the functioning of various electrodes must be due to a difference in their absorbing power for gas (or more strictly their rates of adjustment) and that the maximum break at the end-point will be given with an electrode in which the solution pressure of hydrogen preceding, and oxygen immediately following, the end-point is the greatest possible. Measurements made of electrode potentials with a number of unattackable electrodes in a solution of ferrous sulphate, one-half oxidised with potassium bichromate or permanganate, gave an approximately constant value, indicating that differences in the electrodes can be brought out only at the limiting ion concentration or when the system is out of equilibrium. It is considered that when the concentration of the ion corresponding to either the low or high stage of oxidation becomes vanishingly small its osmotic pressure is no longer greatly in excess of the solution pressure of the gas in the electrode. The latter then becomes the governing factor in determining the potential, and a difference immediately develops between two electrodes possessing varying solvent power for gas. Measurements made in a solution of 0·1N. $FeSO_4$ and 0·1N. $K_2Cr_2O_7$ with various electrodes in conjunction with a silver chloride electrode, showed that a great variation in potential is produced by different pre-treatment of the electrode. Measurements were then made by forcing the system out of equilibrium by means of a polarising current. The procedure consisted in allowing equilibrium to be reached between the electrode and electrolyte and applying, with the help of a third electrode, a small amount of polarising current which was insufficient to cause any appreciable change in the osmotic pressure of the ions present. The magnitude of the potential alteration and the rate at which each electrode returned to the equilibrium potential on breaking the circuit are taken to determine the nature and degree of the solvent power of the metal for hydrogen or oxygen according to the polarity of the applied charge. In view of the magnitude of the polarisation effects observed, experiments were then made in which a low-polarising current was applied as a continuous means of pre-treatment during the course of the titration. Kathodic polarisation has the effect of increasing the apparent strength of the oxidising agent; either increases the end-point break. Considerable differences were shown by different electrodes on polarisation and, of the metals tried, the maximum break was given by pure platinum. With ferrous sulphate in presence of concentrated hydrochloric acid, positive polarisation of the platinum electrode gave an increased break at the end-point, while negative polarisation gave a diminished break. Even more marked results were obtained by dispensing with a third electrode for the polarising circuit and employing two metallic electrodes, making one the positive and the other the negative pole of the polarising circuit. The best results were obtained by having both electrodes of platinum. By reversing the polarity of the electrodes, the break at the end-point differs unless the electrodes are of identical composition, and this effect appears to offer the most sensitive test of the relative purity of platinum. Differences are in this way made apparent which cannot be detected by thermoelectric methods or other means.

J. N. P.

411. *Conductivity of Aqueous Iodic Acid Solutions, and the Limiting Value of the Equivalent Conductivity of the Hydrogen Ion.* **C. A. Kraus** and **H. C. Parker.** (Am. Chem. Soc., J. **44.** pp. 2429–2449, Nov., 1922.)—The apparatus employed and the precautions observed in carrying out conductivity measurements with iodic acid at concentrations down to 5×10^{-5}N are described. The results of measurements made in glass and in quartz cells and with water of various degrees of purity show that the conductivity curve exhibits a maximum due to impurities with water having a specific conductivity above $0{\cdot}1$ to $0{\cdot}2 \times 10^{-6}$. The influence of alkali derived from glass cells is, if anything, greater than that of the impurities present in the water having a specific conductivity of $0{\cdot}8 \times 10^{-6}$.

Conductivity measurements with iodic acid in quartz cells with water having a specific conductivity of $0{\cdot}1 \times 10^{-6}$ have been carried out to concentrations as low as 5×10^{-5}N with a relative precision of a few hundredths of 1 %. Extrapolation on the assumption that the mass-action law is approached as a limiting form at low concentrations gives for Λ_0 of iodic acid at 25° the value of 389·55, which may be accepted as a lower limit to the possible value of this constant. The corresponding mass-action constant is 0·0717, so that iodic acid is a much stronger electrolyte then potassium chloride. For the conductivity of the iodate ion at 25° the value 39·62 is deduced, that of the hydrogen ion being 349·93. At 18° the values will be 34·0 and 315·62 respectively.

T. H. P.

412. *Conductivity of Solutions of Salts in Phenol at 50°.* **C. A. Kraus** and **H. F. Kurtz.** (Am. Chem. Soc., J. **44.** pp. 2463–2468, Nov., 1922.)—The results are given of measurements of the conductivity of (1) Solutions of tetramethylammonium iodide in phenol at 50° for concentrations varying from 1×10^{-4}N to 0·07N; the values of the constants in the conductivity relation, $\frac{(c\gamma)^2}{c(1-\gamma)} = D(c\gamma)^m + K$, are $D = 0{\cdot}70$, $m = 1{\cdot}28$ and $K = 2{\cdot}25 \times 10^{-4}$, and Λ_0 has the value 16·67. (2) Solutions of sodium iodide in phenol at 50° for concentrations ranging from 1×10^{-4} to $1{\cdot}6 \times 10^{-3}$N. The degree of ionisation in this case is far less than with the tetramethylammonium iodide. This difference in behaviour illustrates the fact that, in solvents of low dielectric constant, the electrolyte exhibits, even at low concentration, a much greater degree of individuality than it does in solvents of higher dielectric constant. From the results of cryoscopic measurements on solutions of tetramethylammonium iodide in phenol, Hartung found appreciably greater values of *i* than those corresponding with the values of the conductivity. This discrepancy cannot be due to hydrolysis, as this is found to be inappreciable.

T. H. P.

413. *Electrolytic Oxidation of Alcohols. I. Isoamylalcohol.* **S. Koizumi.** (Kyoto Coll. Sci., Mem. 5. pp. 359–382, July, 1922. In English.)—The electrolytic oxidation of isoamylalcohol to isovaleric acid was brought about by adding the alcohol to a dilute solution of sulphuric acid or sodium hydroxide and arranging it as anolyte in a porous cell with an anode consisting of a lead plate coated with peroxide. The cell was surrounded by the kathode solution consisting of dilute sulphuric acid or sodium hydroxide solution and containing a kathode of nickel mesh. Measurements of the efficiency of the oxidation were made by enclosing the anode vessel, and collecting and measuring the gas evolved. A separate determination was made of the isovaleric aldehyde formed and the isovaleric acid was estimated by titration. A quantity of carbon dioxide was liberated during the reaction. An investigation was made of the influence on the efficiency of the addition of various salts to the anolyte. It was found that in alkaline solutions, the acid formed was always accompanied by the aldehyde; while in sulphuric acid solutions, aldehyde was produced only when a current density of less than 1 amp./dcm.^{2} was used. For the formation of valeric acid, the most favourable concentration of sulphuric acid was found to be 10–20 % and a current density of 1–1·4 amp./dcm.^{2} if the solution was kept stationary or 2 amp./dcm.^{2} when it was stirred. The temperature should be kept below 30° C. A convenient rapid method of electrolysis for preparing the valeric acid without a diaphragm was obtained. In this, the anode consisted of a cylindrical vessel of lead, while the kathode was a nickel wire about 1·5 mm. diameter. The electrolyte consisted of the alcohol dissolved in dilute sulphuric acid. A current efficiency of 56·7 % was obtained. Improved yields were obtained by using an oxygen carrier in the anolyte. The following substances were found most effective: Vanadium pentoxide, cerium sulphate, potassium bichromate, ferrous sulphate. With potassium bichromate a current efficiency of 71·63 % was obtained in the non-diaphragm cell. J. N. P.

414. *Electrolytic Reactions of Naphthalene and its Derivatives. Part I: Electrolytic Oxidation of Naphthalene. Part II: Electrolytic Oxidation of α-Naphthol. Part III; Electrolytic Oxidation of α-Naphthylamine and ar-Tetrahydro-α-Naphthylamine.* **K. Ono.** (Kyoto Coll. Sci., Mem. 5. No. 2. pp. 111–130, Dec., 1921; No. 4. pp. 263–276, Feb., 1922; No. 6. pp. 345–357, July, 1922.)—In acid solution, with lead peroxide or platinum as positive pole, naphthalene is electrolytically oxidised to α-naphthaquinone, which then undergoes further oxidation to phthalic acid and polymerisation to a dark brown substance. α-naphthol is formed as an intermediate product, and the steam distillation products contain a red substance, presumably identical with that obtained by the electrolytic oxidation of α-naphthol. In acid solution, the latter process yields α-naphthaquinone, a compound of α-naphthol with α-naphthaquinone, phthalic acid, and a dark violet compound in the anode chamber, and a red compound (see above) in the kathode chamber. With α-naphthylamine, α-naphthaquinone and a violet colouring matter are obtained as the electrolytic oxidation products, whilst *ar*-tetrahydro-α-naphthylamine gives *ar*-tetrahydro-α-naphthaquinone. Various oxygen-carriers were employed in the above experiments. T. H. P.